(NASA-CR-120429) OPERATIONS PLANNING SIMULATION: MODEL STUDY Final Report (Grumman Aerospace Corp.) ~~161~~ p 166 N74-32404

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GRUMMAN

OPERATIONS PLANNING SIMULATION

MODEL STUDY

FINAL REPORT

REPORT NO. SU OPS-RP-74-0001

PREPARED FOR THE

GEORGE C. MARSHALL SPACE FLIGHT CENTER

HUNTSVILLE, ALABAMA

CONTRACT NUMBER

NAS 8-30302

PREPARED BY

GRUMMAN AEROSPACE CORPORATION

BETHPAGE, L. I., NEW YORK

DATE: 23 May 1974

OPERATIONS PLANNING SIMULATION

MODEL STUDY

EXECUTIVE SUMMARY

PREPARED FOR THE
GEORGE C. MARSHALL SPACE FLIGHT CENTER
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OPS MODEL STUDY

TABLE OF CONTENTS

1.0 OPS MODEL STUDY OBJECTIVES

Four primary objectives of this study were established by mutual agreement of the NASA/GAC study team at the "Study Orientation Meeting". These four objectives are defined in the following sections.

1.1 Describe and demonstrate the methodology used to quantify the resources required in terms of facilities, Ground Support Equipment and manpower.

1.2 Create time distributions for selected functions to be expressed as mean values modified by appropriate density distribution factors.

1.3 Investigation of the reasibility of automating modeling techniques to reduce the amount of time an analyst must spend examining the computer runs, thereby obtaining useful outputs in a shorter period of time.

1.4 Performance of a critique of an existing NASA simulation model in terms of programming, model utilization and output analysis.

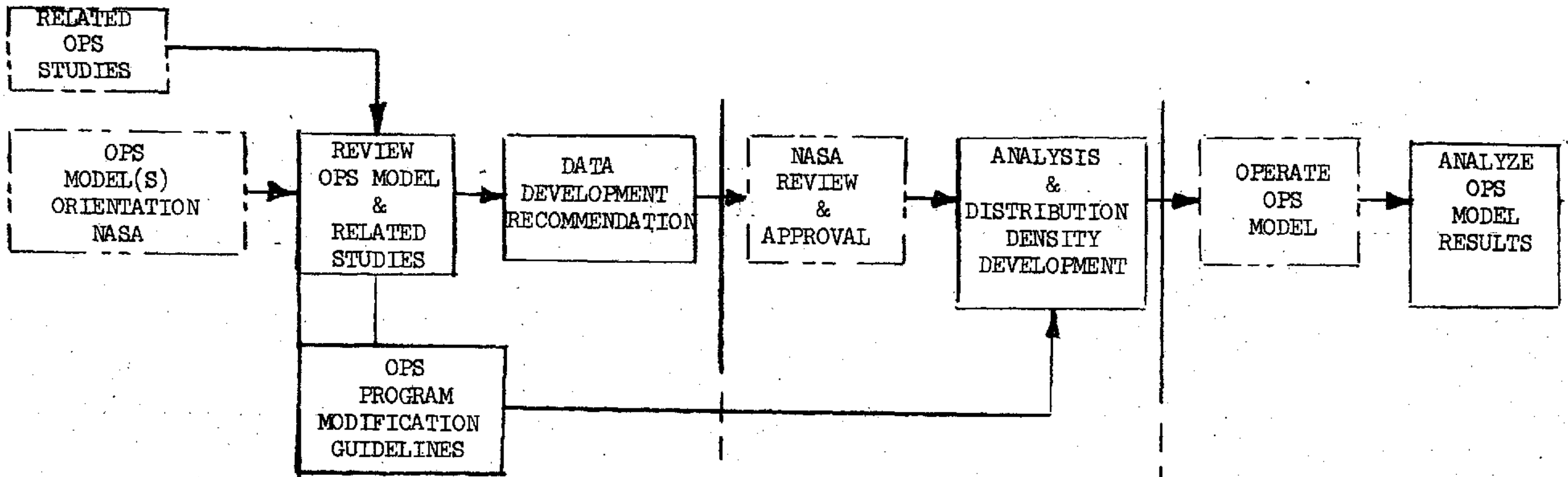
These four objectives are detailed in Appendices A through D of this report.

2.0 STUDY APPROACH

The Program was divided into three phases and the objectives within each phase were identified. Figure 1 shows the flow of these study functions. Those objectives identified in sections 1.3 and 1.4 were completed in phase I while the objectives stated in sections 1.1 and 1.2 were accomplished in Phases II and III.

The data and information generated in Phases I and II were applied to two Sample Cases to demonstrate the techniques involved in the application of this type of data.

STUDY PHASES



STUDY PHASES	PHASE I REVIEW NASA BASELINE DATA & DEVELOP STUDY CONCEPTS	PHASE II ESTABLISH QUANTITATIVE TECHNIQUES FOR SYSTEM ANALYSIS	PHASE III EVALUATE & ANALYZE STUDY RESULTS
TASKS/PHASE	o COMPLETE TASK NO.'S 3 & 4 o DETERMINE REQUIREMENTS ASSOCIATED WITH TASK NO. 2 o IDENTIFY APPROACHES/ CONCEPTS FOR TASK NO. 1	o EVALUATE CRITIQUE OF TASK NO.'S 3 & 4 o PROVIDE 'SAMPLE CASES' FOR TASK NO. 2 o DEVELOP APPROACH/CONCEPT DATA AND 'SAMPLE CASES' FOR APPLICATION - TASK NO. 1	o EVALUATE 'MID-POINT' REVIEW CRITIQUE o ANALYZE 'SAMPLE CASE' OPS COMPUTER RUNS o PREPARE FINAL REPORT AND PRESENTATION

FIGURE 1

2.1 SAMPLE CASES

The methodology used in resource quantification was identical in analyzing both Sample Cases. In Sample Case No. 1, a top level block (Functional Level 0) was taken from the NASA OPS model and expanded to Functional Level II. The block chosen was the function of integrating the Support Unit Simulator and the Experiment Module with Pallet. Tasks within this basic functional block were defined and waterfall time lines were developed.

From the task definitions, resources in terms of facilities, Ground Support Equipment and manpower were derived based on analysis and past experience. In assessing the manpower requirements, the factors affecting availability were involved.

The task times from the waterfall were used in an off-line simulation model which introduced randomness into these times to more realistically represent an actual operation; the result of this program were used in determing resource utilization.

For Sample Case No. 2, the Support Unit Simulator was excluded and the Sample Case examined the mating of the Support Unit itself with the Experiment Module/Pallet combination. The result of the attendant run indicated a reduction of elapsed time compared to Sample Case I.

3.0 CONCLUSIONS

In analyzing the objectives identified in paragraphs 1.1 and 1.2 study resources limited examination of more than the two Sample Cases stated; however, even in this analysis it becomes apparent that sensitivities will be apparent when applying the same methodology to the total functional flow, thereby becoming a valuable tool in early operational planning. Without the use of a simulation modeling technique,

3.0 CONCLUSIONS (continued)

the applications of time variations manually, becomes manpower consuming tasks with results that could come too late to allow effective management decisions.

It is, therefore, recommended that this technique be applied to all of the functional elements in the trunaround flow, tiering the time lines created to gain visibility into possible pitfalls in the flow.

The analysis performed in conjunction with the objective in paragraph 1.3 indicates that the automation of the simulation model, to the extent that the man is removed from the analysis loop is not efficient. A time sharing computer terminal, however, fulfills the needs of MSFC to even a far greater extent. The significant improvement in response time would more than offset the additional investment that would be required for this type of system.

In studying the objectives of paragraph 1.4 we fould NASA's simulation modes to be a fairly accurate representation of one alternative for the Shuttle Payload Ground Operating System. The model, however, still required further expansion and detail in certain critical points in the system. Consideration must also be given to the size of the model. The model must be held in check to prevent it from becoming too large and cumbersome to respond to active analysis.

OPERATIONS PLANNING SIMULATION

MODEL STUDY

APPENDICES

PREPARED FOR THE

GEORGE C. MARSHALL SPACE FLIGHT CENTER
HUNTSVILLE, ALABAMA

CONTRACT NUMBER

NAS 8-30302

PREPARED BY

GRUMMAN AEROSPACE CORPORATION
BETHPAGE, L.I., NEW YORK

DATE: 22 April 1974

OPERATIONS PLANNING SIMULATION MODEL STUDY

Introduction

With the advent of our next step in Space, the Space Transportation System and its highly increased Launch rate, special tools must be developed to permit rapid management decisions. Simulation modeling is such a tool to be used for the identification of system sensitivities to internal and external influences and variables. Further, it provides a means of exploring alternate system procedures and processes, so that these alternates may be considered on a mutually comparative basis permitting the selection of a mode or modes of operation which have potential advantages to the system user and operator.

These advantages are measurements of system efficiency; such as, the ability to meet specific schedules for operations, mission or mission readiness requirements, or performance standards and last but most significant to accomplish these objectives within cost effective limits. It is the prerogative of management to evaluate the data developed by the analyst through the simulation modeling technique and his interpretation of sensitive elements in the system, and to select the system alternate or alternates which should either further be studied or implemented.

Consequently, if the products of simulation modeling are to have significance, they must be in terms which are meaningful at management levels. Hence, terms which reflect mission performance parameters referenced to operational resource costs are necessary. If true cost data are not available but the outputs are in costable units, such as, square feet of facility space, or in skills and numbers of people for manpower, etc., then a comparative evaluation with realistic terms can be made. The purpose of the following guidelines, concepts, and technical data is to aid and assist the analyst in developing OPS model outputs which are more generally understood and interpreted.

Introduction (continued)

Four (4) study tasks were established by the mutual agreement of the NASA/GAC study team at the "Study Orientation Meeting" held on 2 and 3 October 1973, at Marshall Space Flight Center. The result of these tasks, described below, are included as Appendices A through D, respectively, in this final report.

Study Task No. 1 (Appendix A) was structured to define the methodology used to develop certain curves, tables, and matrices to quantify resources in terms of facilities, ground support equipment, and operational manpower. These guidelines, approaches, and technical data when applied to the OPS model analysis will effect the model so that outputs will furnish users with information of increased meaning.

The purpose of Task No. 2 (Appendix B) was to develop data which closely reflects "real-world" situations. The constant use of "Averages" or "Means" instead of random or varying processing "times" neglects an important consideration in the overall Shuttle payload ground operations system.

When all activities and tasks are accomplished in a precise amount of time, events can be scheduled with a great degree of certainty. As these processing "times" become less and less constant and start to vary, delays or blockages in the system start to occur. These delays can have an adverse effect on the ability to meet the launch schedule, and must be taken into account. This is normally done by expressing the processing "time" in terms of a Mean Value and a modifying density distribution function.

Study Task No. 3 (Appendix C) was to investigate the feasibility of automating modeling techniques for the purpose of determining capacities and quantities. This task attempts to reduce the amount of time an analyst must spend examining the computer runs, thus obtaining useful outputs in a shorter period of time than is currently being realized.

Introduction (continued)

Study Task No. 4 (Appendix D) was to make NASA analysts at MSFC the beneficiary of GAC's many years of experience in the field of simulation modeling. GAC has some nine (9) years experience in developing computer simulation models for analysis and quantification of support resources (i.e. facilities, equipment, spares, personnel, etc.).

OPS MODEL STUDY

APPENDIX A

RECOMMENDATIONS FOR EFFECTING OPS MODEL OUTPUTS IN QUANTITATIVE TERMS FOR OPERATIONS RESOURCE REQUIREMENTS

REPORT NO. SU-OPS-RP-73-0002A

PREPARED FOR THE

GEORGE C. MARSHALL SPACE FLIGHT CENTER
HUNTSVILLE, ALABAMA

CONTRACT NUMBER

NAS 8-30302

PREPARED BY

GRUMMAN AEROSPACE CORPORATION
BETHPAGE, L. I., N. Y.

DATE: 4/11/74

OPS MODEL STUDY

APPENDIX A

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APPENDIX A

1.0 STUDY TASK

This task was structured to define the methodology used to quantify resource requirements needed in the Central Integration Facility (CIF) for the turnaround functions of the Support Unit, Experiment Module, and the experiments.

2.0 GENERAL INFORMATION

2.1 DEPTH OF ANALYSIS

Off-line analysis to be effective must be carried to a depth greater than that represented by the simulation model flow diagram. Depending upon constraints and information desired, this depth must be at least one (1) level deeper. For most applications a "cut" of more than one (1) level is required.

Figure No. 2-1, "OPS Model Evolution," shows the relationship between off-line analysis and simulation modeling for various levels of modeling studies. In addition, a brief description in diagram format show the level of detail of input data and output information.

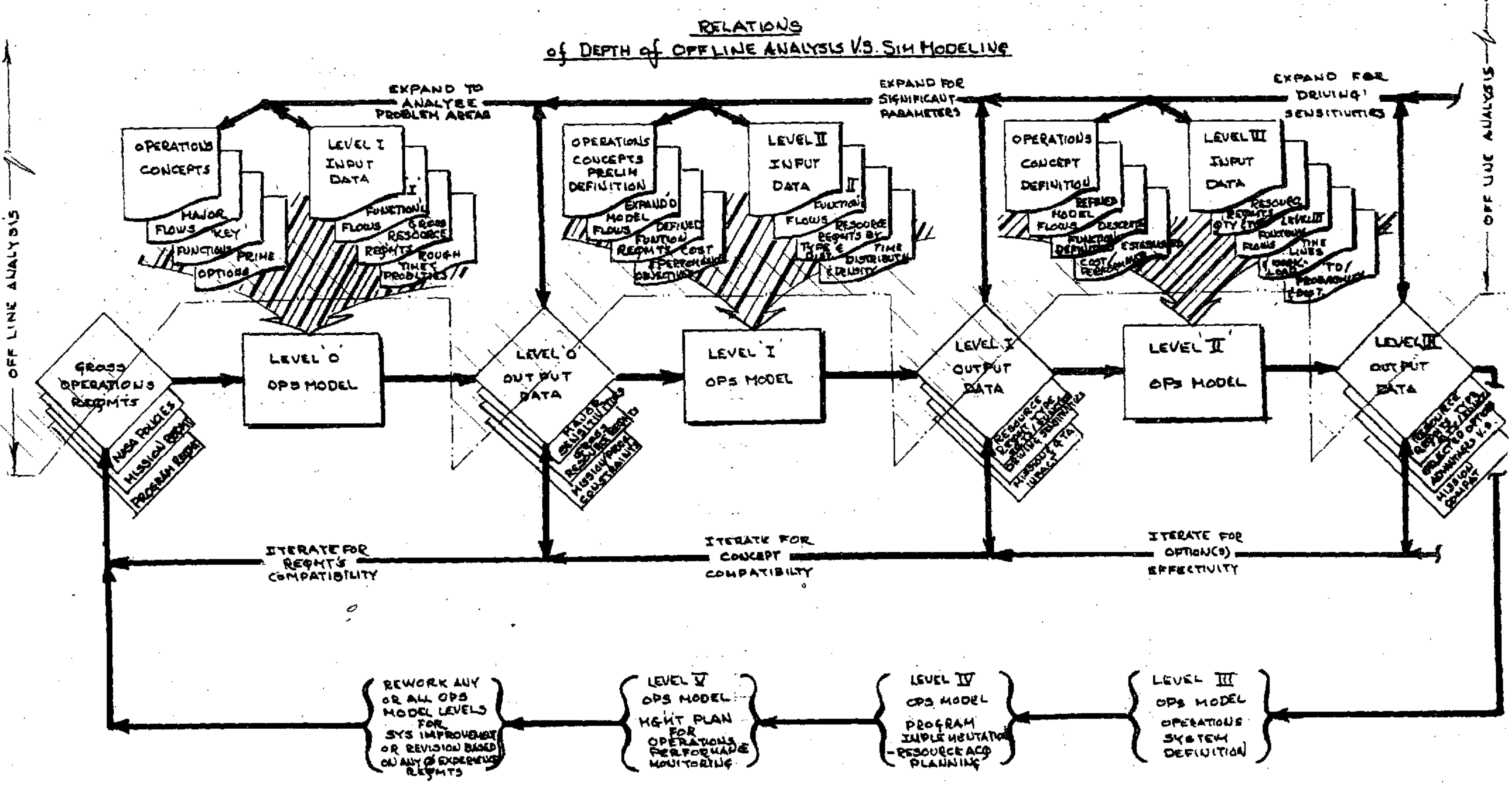
2.1.1 Factors Affecting Depth of Analysis

The limits and requirements affecting the depth of analysis possible and required are:

a) The level of intelligence and information available about the operational concept.
b) The potential impact on system performance.
c) The cost parameters of the operations option(s) under study.

FIGURE № 2-1

OPS MODEL EVOLUTION



OPS MODEL EVOLUTION

Fig № 2-1
Pg №

2.1.1 Factors Affecting Depth of Analysis - (Continued)

Item (a) is the least containing element for initial study operations (levels 1 and 2) due to the fact that most systems can by hypothesized to a reasonable degree of validity. However, it is important that the ground rules used and the asseumptions made are clearly stated for the users consideration. In addition, the ground rules and assumptions should be updated to reflect the latest information as the concept matures and evolves.

Item (b) should result as a direct output of the model. Model flow paths and modes which generate queing effects in the process, require large amounts of resources, and affect schedules, mission readiness, etc generate requirements for greater depth of analysis and system exploration.

2.1.2 Cost Considerations

Item 2.1.1 (c) above, cost parametersm is the most important factor relative to the depth of analysis, due to fact that it is the most utilized criteria for judging system option advantages or disadvantages. The prime cost considerations involve two (2) major elements:

a) Peak annual funding requirements
b) Program life cycle costing

Both of the above are influenced by a further breakdown in cost elements and the overlap of the parts of this breakdown in program phasing. These are:

c) Development cost
d) Operational cost

The overlap of (c) and (d) above is a function of:

e) Program major milestones
f) Mission requirements
g) Procurement, requirement justification and development lead times.

2.1.3 Resource Requirements and Cost

Operations resource requirements which influence cost relationships are:

- o Fleet size - number of flight articles
- o Site requirements - number, location, and type
- o Facility requirements - No., type, size, utilization
- o GSE - quantity, type, utilization
- o Spares - flight articles and GSE
- o Manpower - Ops crew size and skills
- o Transportation & Handling - inter & intra site ground turnaround
- o Training - for unique skills acquisition and maintenance
- o Publications - technical data necessary for implementation of operations.

These resource elements are influenced by the functions in 2.1.2 (e), (f) & (g) and in turn influence the cost elements in (a), (b), (c) & (d). The improvement of system effectiveness involves trade-off studies between the functional elements (2.1.2 - e, f, & g), their subsequent impact on resource requirements and the total influence on cost parameters.

Table 2-1, "Operations Resource Commodities, Cost Considerations" show the major cost aspects for various resource commodities in diagram format. The relative values shown are referenced to the total program cost. In addition, average funding lead times are shown and general amortization periods indicated.

TABLE 2-1

LEVEL I
OPERATIONS RESOURCE COMODITIES
COST CONSIDERATIONS

KEY: COST ASPECT; YEARS LEAD TIME

Level I ⟶ Level I+

(1) RESOURCE	(2) UNIT OF MEASURE	DEVELOPMENT ∅ (3) R&D	(4) ACQUISIT	(5) ACTIVATION	OPERATIONAL ∅ (6) ACQUISIT	(7) MAINT	(8) OPERAT'N	(9) AMORTIZATION
(A) FLEET SIZE	No. & TYPE OF FLT ARTICLE &/OR MODULES	2-5	2-10	2	2-5	L	L	L
(B) SITE REQMT'S	No. & TYPE + SPECIAL REQMTS LOCATION	2	3-5	3	2-3	P	P	P
(C) FACILITY REQMT'S	No./SITE /FUNCT'N	2	3-6	3	2-3	P	P	10
(D) GSE	SET/ FUNCTION	2-3	2-4	2	2-3	P	N/A	10
(E) SPARES	SET/FLT ARTICLE OR MODULE SET/SET GSE	2	2-10	1	2-5	P	N/A	L
(F) MANPOWER	CREW REQ'D/ FUNCTION	2	1	1	2	0-2	SP P	P
(G) TRANSPORTATION & HANDLING	MODE/ SITE MODE/ FUNCTION	3	3 4	1	1-4	SP 0-5	SP P	P
(H) TRAINING	COURSE /SKILL/ REQMT/ FUNCTION	3	3	1	0-3	0-5	N/A	P
(I) PUBLICATIONS	SET/ SKILL/ FUNCTION	3	3	1	0-3	0-5	N/A	P

Level I ⟶ Level I+

LEGEND

L - LIFE OF ITEM

P - LENGTH (IN TIME) OF PROGRAM

~ VERY HIGH COST

~ HIGH COST

(SP) ~ SPECIAL CASE ie. B.T. & OPERATE,

~ MODERATE COST

~ NOMINAL COST

~ MINIMUM COST

NOTES:

(1) COST ASPECTS ARE RELATIVE TO TOTAL PROGRAM

(2) - LEAD TIMES REFERENCED TO REQ'MT JUSTIFICATION - EXCEPTION (5) "ACTIVATION" WHICH IS REFERENCED TO START DATE FOR OPS ∅

2.1.4 Model Flow Diagram

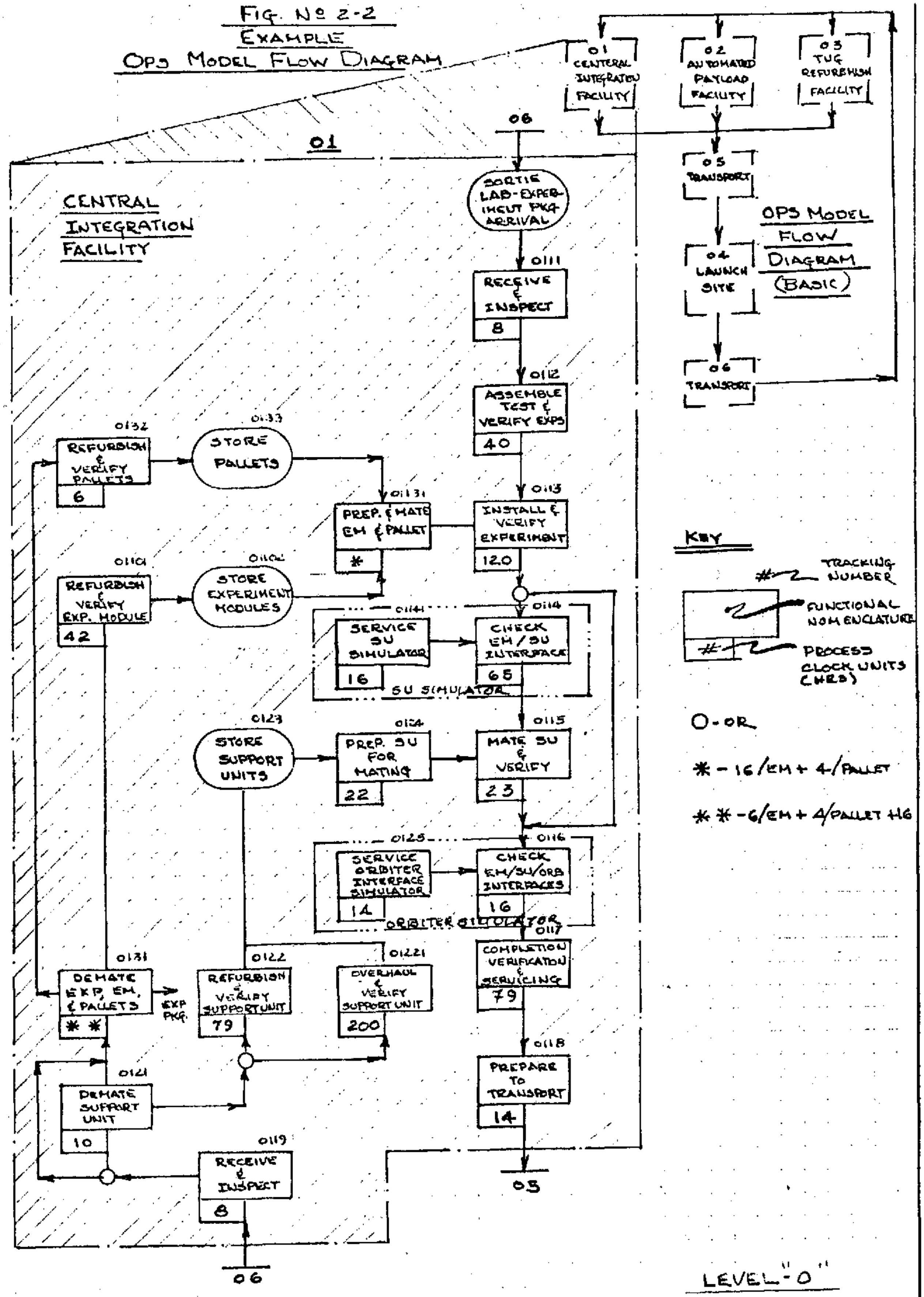
Figure No. 2-2 shows an example of the OPS Model flow diagram. In the actual development of a flow diagram, logical segments of the system are first established through flowcharts. Starting with blocks which represent the major functions of the proposed system, more detailed logic is then introduced by adding blocks to depict more detailed operations.

After the overall logic of the system is established, certain segments are extracted from the general diagram and analyzed in greater depth. Proceeding in this manner, the block diagram becomes more detailed. The amount of detail depends upon the purpose and depth of analysis that is required. The goal is to produce a diagram which clearly shows all decision points in the system and which can be used to verify all possible conditions which arise during the operation of such a system (note that such a diagram is a model of the system).

Block diagrams provide the system analyst with a means of visualizing the sequence in which the logical and arithmetic operations take place within the system, as well as the relationship of one portion of the system to another.

It is usually desirable to keep the flow diagram as simple as possible consistent with system complexity and yet provide sufficient data so that the system can be understood. It is

FIG. No 2-2
EXAMPLE
OPS MODEL FLOW DIAGRAM



LEVEL "0"

EXAMPLE
OPS MODEL FLOW DIAGRAM

Fig. No. 2-2
Pg. No. 23

more effective, if expansion of a portion of the flow is required for further investigation, to perform this as an "off line" effort and incorporate the output of this analysis as an input to determine the influence of that element on the remainder of the system. This procedure is further discussed in later sections of this report. See Sections 2.1.5 and 2.1.6.

2.1.5 Sel ion Criteria

Unless the study effort is to be very rigorously persued, there is usually little to be gained by exploring or expanding every facet of model. Hence, to be productive, the selection of model paths for further analytic treatment, such as functional flow analysis, time line development, etc., an ordering of priorities in analytic treatment is required. This ordering should allow the analyst to obtain the greatest amount of useful quantitative information for a specific level of analytic depth with the least amount of model complication. The priorities for selection include:

a) Those paths or nodes that involve the greatest number of the resources (see 2.1.3)

b) Those paths, loops, and flows which generate process queing effects (see 2.1.1-b)

c) Those parts of the model that involve the greatest number of elements in (a) above which may be considered "cost drivers" for the level of analysis in work or for the program phase under study.

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2.1.6 Selection Application Procedures - "Off-Line" Analysis

There are no hard and fast rules for developing "off-line" analytic data. In any on-going model study, many efforts take place in parallel. As iterative analysis steps are performed and knowledge of the system sensitivities is acquired, certain "short-cut" steps become evident and some serial efforts can be deleted. Thus, in time "off-line" data and model outputs can be generated more effectively for selected applications.

While as mentioned, rules for application procedures are not hard and fast. (In fact a flexible approach offers the analyst some advantages depending on the response and type of data required). Certain basic steps seem to provide the best option for the generation of reasonable quantative data, (at least in the preliminary phases of analysis). These include the development of:

- o Functional flow diagrams.
- o Task scenarios (per major function)
- o Operational "time-lines"
- o Assign time distributions and probability parameters for selected functions (See Task No. 2, Report No. Su-OPS-73-0002B).
- o Resource allocation by function, event and/or activity.
- o Equipment, resource, and facility requirements data lists, tables, planning curves and criteria.

APPENDIX A

2.1.6.1 Functional Flow Diagrams

A function flow diagram is a pictorial representation of the steps, tasks and events involved in the accomplishment of a given process. Generally, the steps or blocks are arranged in the chronological order of occurence within the process under analysis. Sequential and parallel functions are shown and decision points highlighted.

Figure 2-2 shows an example of the OPS model flow diagram and while this is a pictorial model of the computer simulation model it is also a functional flow diagram of the payload (Central Integration Facility) processing system. If the model flow diagram is considered a "level 0" diagram of the system, analytic processing of a greater depth is required to determine additional information about the system.

Figure 2-3 shows the diagram of the simulators (Support Unit & Orbiter) of one level of greater depth than the "level 0" shown in the Fig 2-2 , and additional decision points appear. Figure 2-4 is again an additional increase in the depth of analysis. This shows the functional flow to a level II for the support unit simulator. Again new flow paths are uncovered and additional system information is made clear. For this system additional levels of analysis will not yield much greater information about the system. Depending upon system complexity, the analyst is usually the best judge as to the number of levels (of depth of analysis) required to produce meaningful information about the system. In working the problem he can usually tell because of the knowledge gained in each step whether or not an additional

APPENDIX A

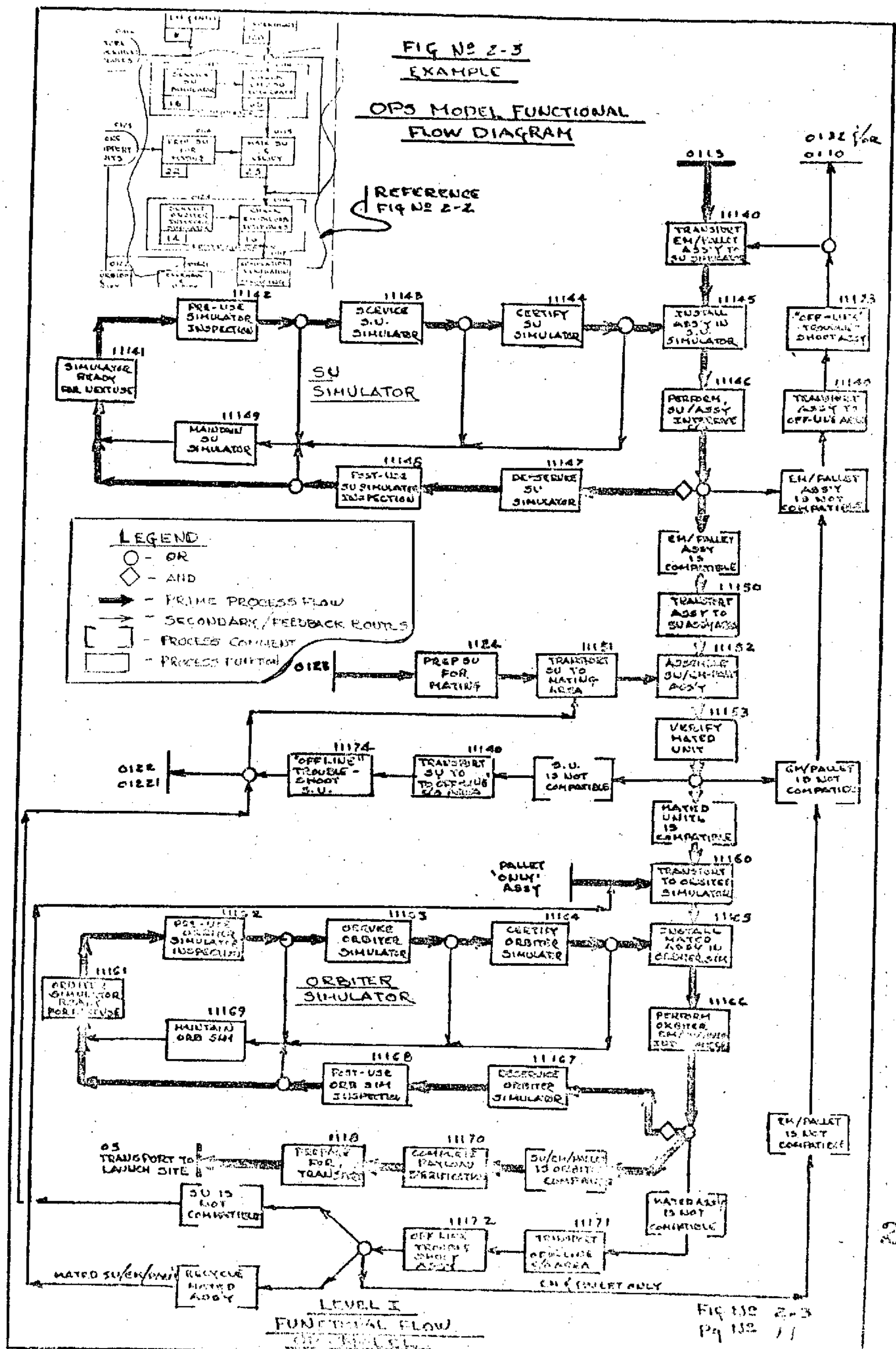


FIG No 2-3
EXAMPLE
OPS MODEL FUNCTIONAL FLOW DIAGRAM
REFERENCE FIG No 2-2
LEGEND
- OR
- AND
- PRIME PROCESS FLOW
- SECONDARY/FEEDBACK ROUTES
- PROCESS CONTENT
- PROCESS FUNCTION
0115
0132 f/or 0110
11140 TRANSPORT EM/PALLET ASS'Y TO SU SIMULATOR
11142 PRE-USE SIMULATOR INSPECTION
11143 SERVICE S.U. SIMULATOR
11144 CERTIFY SU SIMULATOR
11145 INSTALL ASS'Y IN S.U. SIMULATOR
11141 SIMULATOR READY FOR NEXT USE
SU SIMULATOR
11149 MAINTAIN SU SIMULATOR
11146 PERFORM SU/ASSY INTERFACE
11148 POST-USE SU SIMULATOR INSPECTION
11147 DE-SERVICE SU SIMULATOR
11173 "OFF-LINE" TROUBLE SHOOT ASSY
EM/PALLET ASS'Y IS NOT COMPATIBLE
EM/PALLET ASSY IS COMPATIBLE
11150 TRANSPORT ASSY TO SU ASSY AREA
0123
1124 PREP SU FOR MATING
11151 TRANSPORT SU TO MATING AREA
11152 ASSEMBLE SU/EM-PALLET ASS'Y
11153 VERIFY MATED UNIT
0122
01221
11174 "OFFLINE" TROUBLE-SHOOT S.U.
S.U. IS NOT COMPATIBLE
EM/PALLET IS NOT COMPATIBLE
MATED UNIT IS COMPATIBLE
PALLET "ONLY" ASSY
11160 TRANSPORT TO ORBITER SIMULATOR
11163 SERVICE ORBITER SIMULATOR
11164 CERTIFY ORBITER SIMULATOR
11165 INSTALL MATED ASSY IN ORBITER SIM
11161 ORBITER SIMULATOR READY FOR NEXT USE
ORBITER SIMULATOR
11169 MAINTAIN ORB SIM
11166 PERFORM ORBITER
11168 POST-USE ORB SIM INSPECTION
11167 DESERVICE ORBITER SIMULATOR
05 TRANSPORT TO LAUNCH SITE
1118 PREPARE FOR TRANSPORT
11170 COMPLETE PAYLOAD VERIFICATION
SU/EM/PALLET IS ORBITER COMPATIBLE
EM/PALLET IS NOT COMPATIBLE
SU IS NOT COMPATIBLE
MATED ASSY IS NOT COMPATIBLE
11172 OFF LINE TROUBLE SHOOT ASSY
11171 TRANSPORT
MATED SU/EM/PAL
RECYCLE MATED ASS'Y
EM & PALLET ONLY
LEVEL I
FUNCTIONAL FLOW
Fig No 2-3
Pg No 11

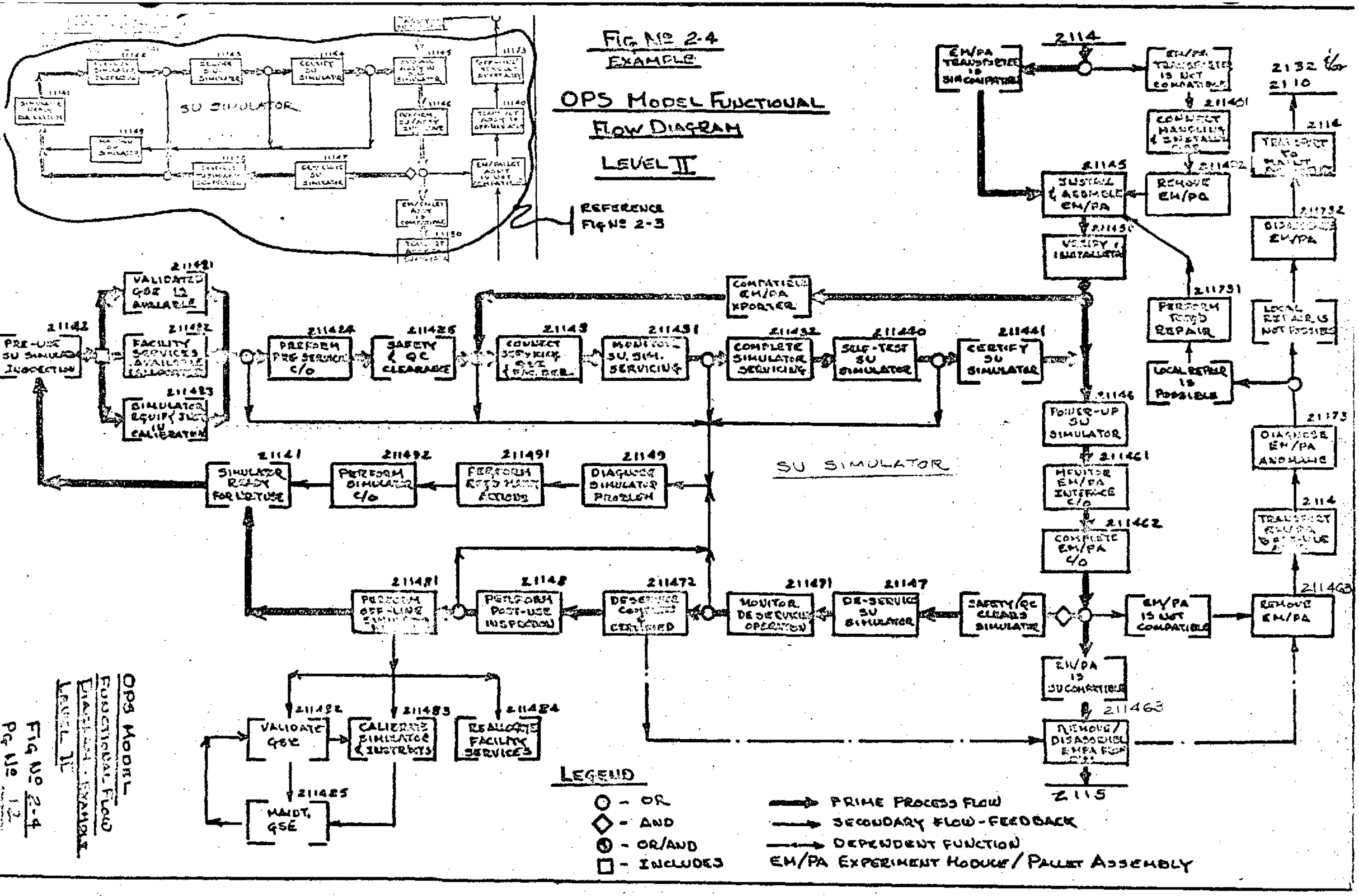


FIG No 2-4
EXAMPLE
OPS MODEL FUNCTIONAL
FLOW DIAGRAM
LEVEL II
REFERENCE
FIG No 2-3
SU SIMULATOR
2114
EM/PA TRANSPORTER IS SU COMPATIBLE
EM/PA TRANSPORTER IS NOT COMPATIBLE
211401
CORRECT HANDLING & INSTALLATION
211402
REMOVE EM/PA
21145
INSTALL & ASSEMBLE EM/PA
211450
VERIFY INSTALLATION
2132 to 2110
2114
TRANSPORT TO MAINT. FACILITY
211732
DISASSEMBLE EM/PA
211731
PERFORM RQ'D REPAIR
LOCAL REPAIR IS NOT POSSIBLE
LOCAL REPAIR IS POSSIBLE
21173
DIAGNOSE EM/PA AND MAINT.
2114
TRANSPORT EM/PA
211463
REMOVE EM/PA
EM/PA IS NOT COMPATIBLE
21142
PRE-USE SU SIMULATOR INSPECTION
211421
VALIDATED GSE IS AVAILABLE
211422
FACILITY SERVICES AVAILABLE
211423
SIMULATOR EQUIP & INST. IN CALIBRATION
211424
PERFORM PRE SERVICE C/O
211425
SAFETY & QC CLEARANCE
21143
CONNECT SERVICING GSE & FAC. REQ.
211431
MONITOR SU SIM. SERVICING
211432
COMPLETE SIMULATOR SERVICING
211440
SELF-TEST SU SIMULATOR
211441
CERTIFY SU SIMULATOR
COMPATIBLE EM/PA XPORTER
21146
POWER-UP SU SIMULATOR
211461
MONITOR EM/PA INTERFACE C/O
211462
COMPLETE EM/PA C/O
EM/PA IS SU COMPATIBLE
211463
REMOVE/ DISASSEMBLE EM/PA FOR
2115
21141
SIMULATOR READY FOR RE-USE
211492
PERFORM SIMULATOR C/O
211491
PERFORM RFQ'D MAINT ACTIONS
21149
DIAGNOSE SIMULATOR PROBLEM
211481
PERFORM OFF-LINE
21148
PERFORM POST-USE INSPECTION
211472
DE-SERVICE COMPLETED & CERTIFIED
211471
MONITOR DE-SERVICE OPERATION
21147
DE-SERVICE SU SIMULATOR
SAFETY/QC CLEARS SIMULATOR
211482
VALIDATE GSE
211483
CALIBRATE SIMULATOR & INSTRMTS
211484
REALLOCATE FACILITY SERVICES
211485
MAINT. GSE
LEGEND
○ - OR
◇ - AND
- OR/AND
□ - INCLUDES
PRIME PROCESS FLOW
SECONDARY FLOW-FEEDBACK
DEPENDENT FUNCTION
EM/PA EXPERIMENT MODULE/PALLET ASSEMBLY
OPS MODEL
FUNCTIONAL FLOW
DIAGRAM - EXAMPLE
LEVEL II
Fig No 2-4
Pg No 12

83

level will yield significant system information.

2.1.6.2 Interim Summary

At this point, a review of the material covered up to this part of the study is in order. Initially, ground rules governing the required depth of analysis to investigate system sensitivities and approach the quantification of resource requirements were presented. Next the influence of cost criteria and resource requirements were examined with the objective of identifying operations resource requirements which have a tendency to be system cost "drivers". The NASA/MSFC OPS Model was then evaluated and in an approach to develop "sample case" examples, the portion of the model dealing with the Central Integration Facility (CIF - Sortie Lab) was selected for further investigation. A Level I and II functional flow diagram was developed for the simulator section of the model since this part of the CIF flow closely satisfies the conditions stated in Section 2.1.5 "Selection Criteria".

The completion of the functional flow analysis to a suitable depth, (Level II in this case) provides a convenient break point for "off-line" analysis. Armed with the model flow diagram and the functional analysis, data specialists can commense investigations into, at the very least, gross operations resource requirements. The following portion of this report will present a sequential method of determining these requirements. However, if rapid response is required many of the following operations can be conducted in a parallel fashion.

2.1.6.3 Operational Task Scenarios

An initial step in the development processing time requirements and constraints is the generation of Task Scenarios for specific functions. In developing this data, a functional flow (in this case the SU Simulator Level II) is evaluated by identifying the operational tasks required to accomplish each established function in the flow, Table 2-4 shows an example of this type of data.

2.1.6.4 Operational Task - Time Allocations

Table 2-4 in addition to showing the Operational Task Scenarios, also shows process/task time allocations for each major function under the column marked "t_{ot}". In addition those processes which have variable processing times are indicated; such as, maintenance functions. The indicated time allocations were made to be consistent with the block times indicated in the Model flow diagram Figure No. 2-2. A latter phase of analysis requires an evaluation of these time allocations to determine whether or not these are realistic or must be modified to obtain "real world" results.

Table 2-4, also shows in the column marked "Pr" the probability of a change in process flow required by either a rejection of the flight hardware under test or a fault in the test equipment. Discussions in the Test Report No. 2 (SU OPSRP-73-0002B) will explane the application of time density functions and probability parameters to these functions as a typical application of this type of data in simulation modeling.

TABLE NO. 2-4

OPERATIONAL TASK SCENARIO

S.U. SIMULATOR

t_{OT}	FUNCTIONAL FLOW		OPERATIONAL TASK	P_r
	BLOCK NO.	NOMENCLATURE	DESCRIPTION	
3 hrs	211420	Pre-use Inspection S.U. Simulator	o Visual Inspection of Sim. o Remove all Dust Covers & protective packaging	
	211421	Validated GSE is available	o Servicing GSE Functional set is ready i.e. "In Calib" & validated for next use	
	211422	Facility Services are abailable & allocated	o Proper Power & Pressures are available at sim. o Consumables have been allocated for next-use	0-5% 211490
	211423	Simulator Equip & Instruments are "In-Claibration"	o Check all instruments & equip for current Calib. certification	
	211424	Perform pre-servicing check-out	o Perform limited sim. self-test - Gauge & instruments are functioning - Simulator is ready for servicing	
	211425	Safety & Q.C. Clearance	o Follow-up/Check pre-servicing. Conditions have been met	0-2% 211490
6.5 hrs	211430	Connect all servicing GSE & Facility services	o Connect electrical cable assemblies o Connect all hoses & Flex tubing	
	211431	Monitor S.U. simulator servicing	o Observe all servicing procedures o Record critical data i.e. rates, levels, flows, pressures, voltage, curreny, signals, etc.	0-10% 211490

t_{OT} = MEAN TIME ALLOCATED FOR OPS TASK

P_r = Probability of REJECTION
% = TOTAL REJECTED
# = FUNCTION REJECTED TO

TABLE NO. 2-4

OPERATIONAL TASK SCENARIO

SU SIMULATOR

t_{ot}	FUNCTIONAL FLOW		OPERATIONAL TASK	P_r
	BLOCK NO.	NOMENCLATURE	DESCRIPTION	
	211432	Complete Sim. servicing	o Top off all servicing functions o Complete servicing operations o Disconnect applicable GSE	
1.5 hrs	211440	Self Test SU Simulator	o Run self-test procedure to determine readiness of serviced simulator for EM/PA interface C/O	0-2% 211420
	211441	Certify SU simulator	o Test Conductor/Authorized witness certifies Sim. is ready for EM/PA interface C/O	
	211401	Connect Handling & Installation GSE	o Connect lifting slings (EM/PA) and adapters o Schedule crane in place for load removal o Clear area	
	211402	Remove EM/PA	o Release EM/PA hold-downs on transporter o Take up on load o Lift out of transporter	
9 hrs	211450	Install EM/PA & assemble in simulator	o Move Via crane adjacent to SU simulator o Remove protective coverings & dust covers o Lower in place in simulator o Align EM/PA in simulator o Lock-down assembly o Make-up all required connections.	0-1% 211400

TABLE NO. 2-4

OPERATIONAL TASK SCENARIO

SU SIMULATOR

t_{ot}	FUNCTIONAL FLOW		OPERATIONAL TASK	Pr
	BLOCK NO.	NOMENCLATURE	DESCRIPTION	
3 hr *	211450	(Optional-if EM/PA transporter is SU simulator compatible) Install EM/PA & assemble in simulator	o Move EM/PA transporter adjacent to sim. o Remove protective coverings & dust covers o Align transporter & assembly to simulator o Mount in place o Make-up all required connections	0-1% 211400 *
5 hrs	211460	Power-up SU simulator	o Open all required vent valves o Bring up elect. Pwr o Build-up required pressures o Commense initial signals for end-to-end SU/EM/PA check-out	—
45 hrs	211461	Monitor EM/PA Interface C/O	o Observe all SU interface procedures o Record all critical interface data o Monitor test self protection Ckt's & devices	0-5% 211490
15 hrs	211462	Complete EM/PA SU interface C/O	o Complete all EM/PA interface procedures o Power-down simulator o Remove all pressures & safety all lines o Purge & Decontaminate all required lines, ducts, & surfaces o Evaluate Test & C/O Data	—

* APPLIES ONLY IF THIS OPTION SELECTED

TABLE NO. 2-4

OPERATIONAL TASK SCENARIO

S.U. SIMULATOR

t_{ot}	FUNCTIONAL FLOW		OPERATIONAL TASK	P_r
	BLOCK NO.	NOMENCLATURE	DESCRIPTION	
3 hrs	211463	Remove EM/PA from SU simulator	o Disconnect all interfaces with SU simulator o Install all protective covers o Install handling & transportation GSE o Position overhead crane & install lifting sling o Lift EM/PA free of simulator o Transport via crane to transporter o Install in transporter o Connect all EM/PA o Disconnect all handling GSE	
1 hr	211400	Transport EM/PA to off-line area (optional)	o Remove transporter from production flow area away from SU simulator	0-10% 211790
1-16 hr	211790	Diagnose EM/PA a nomalie (optional)	o With suitable GSE determine if local minor repair of non compatible EM/PA is possible o Evaluate data from off-line & SU simulator tests	
1-16 hr	211791	Perform required repair (optional)	o Perform local (minor) repair or adjustment o Inspect workmanship of repair action o Prep for re-installation SU simulator	Z

TABLE NO. 2-4

OPERATIONAL TASK SCENARIO

S.U. SIMULATOR

t tot	FUNCTIONAL FLOW		OPERATIONAL TASK	Pr
	BLOCK NO.	NOMENCLATURE	DESCRIPTION	
1 hr	211400	Transport to maint. facilities (optional)	o Transport EM &/or pallets to maintenance activities	
	211470	De-service SU simulator	o Preform all preliminary de-servicing procedures o Preform required safety inspections - Vents & purge lines clear - Required jury struts in place o Connect required GSE (functional set for de-servicing)	0-5%
3.5 hrs	211471	Monitor de-servicing operation	o Observe de-service ~~OPS~~ o Record all critical data o Monitor protective ~~CKTS~~ and devices	211490
	211672	De-service complete & certify	o Complete de-service o Clean/de contaninate all lines o Power down simulator o Authorize test conductor/ witness certifies safe de-servicing de-serviced condition	

TABLE NO. 2-4

OPERATIONAL TASK SCENARIO

S.U. SIMULATOR

t_{ot}	FUNCTIONAL FLOW		OPERATIONAL TASK	P_r
	BLOCK NO.	NOMENCLAUTURE	DESCRIPTION	
1.5 hr	211480	Perform post-use inspection	o Perform Su simulator post-use self test o Perform simulator off line C/O with portable test equip. o Do routine preventative maintenance o Install protective covers & packaging	0-2% 211490
—	211410	Simulator ready for next use	o Evaluate test & maint. data o Authorized personnel certifies readiness o Process control notified, simulator ready for next use	—
1-16 hrs	211490	Diagnose simulator problem	o Perform available self-test procedures o Perform off-line test checks	—
8-40 hrs	211491	Perform required maint. action	o Remove isolated fault or faulty component o Replace component/repair fault	—
1-40 hrs	211492	Perform simulator check-out	o Retest for fault correction o Perform all recertification test procedures o Certify simulator readiness for use	—
—	211481	Perform off-line simulator functions	o See below	—

TABLE NO. 2-4

OPERATIONAL TASK SCENARIO

S.U. SIMULATOR

t_{ot}	FUNCTIONAL FLOW		OPERATIONAL TASK	P_r
	BLOCK NO.	NOMENCLATURE	DESCRIPTION	
8 hrs	211482	Validate GSE (each use or pre-determined frequency)	o Perform GSE test to insure readiness for next use o GSE validation equip. calibration per determined frequency	Ea. Use
16 hrs	211485	Maintain GSE	o Perform test to isolate fault or bad component o Repair fault/replace component o Per form validated C/O 211482	1 of Ea. 4 uses
40 hrs	211483	Calibrate simulator equip. & instruments	o At given cycle time recalibrate inst's & equip. o Local calibration o Lab calibration	1 of Ea. 6 uses
8 hrs	211483	Re-allocate facility services	o Speciality power requirements pre process schedule o Determine rate of consumables utilization o Allocate requirements for consumables	Ea. Use
2 hrs **	211792	Disassemble EM/PA (optional if local repair is not possible ** ONLY IF OPTION IS SELECTED	o Remove protective covers o Disassemble unit (can be done in off-line area or at the original ass'y point. o Disconnect all hard points & interfaces o Install in component transporters o Lock all component hold downs	—

APPENDIX A

2.2 QUANTIFICATION OF RESOURCE REQUIREMENTS

2.2.1 General Background

If Table 2-1 is perused, it can be readially be determined that the cost drivers in any aerospace system are:

a) Fleet size - number of flight articles

b) Site requirements - number, location and type

c) Facility requirements - No., type, size, utilization

d) GSE - quantity, type, utilization

e) Spares - for flight articles and GSE

f) Manpower - crew size and skills

Items (a) and (b) are usually fixed to some extend, at least in the initial system appraisals. Subsequent, analytic iterations usuall consist of comparing various operating modes and alterations of these items to optimize the system or to measure the influence of these variations on the quantities & cost of the remaining resources.

Item (e) is responsive to system parameters in somewhat a different manner than the other resources. Mean Time Between Failure (MTBF), Mean Time To Repair (MTTR), and other maintainability factors cause pertubations in quantifing this resource requirements. The net result is that spares are usually considered in a separate off-line analysis. This can be done as a separate model so that the influence of alternate operations, changes in maintainability factors or other operations can be readilly acessed.

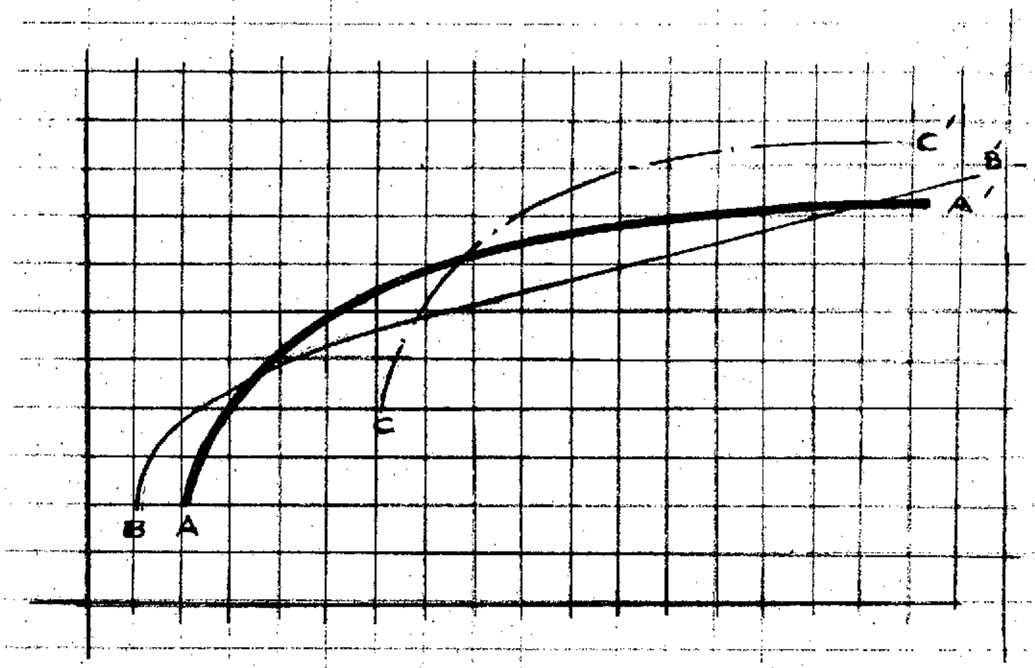
APPENDIX A

2.2.2 Resource Requirements - General

Resource requirements, particularly those listed in (c), (d), and (f) above (Sect. 2.2.1) behave in a non-linear fashion with respect to work load. Figure No. 2-5 below shows this relationship.

FIG. No. 2-5

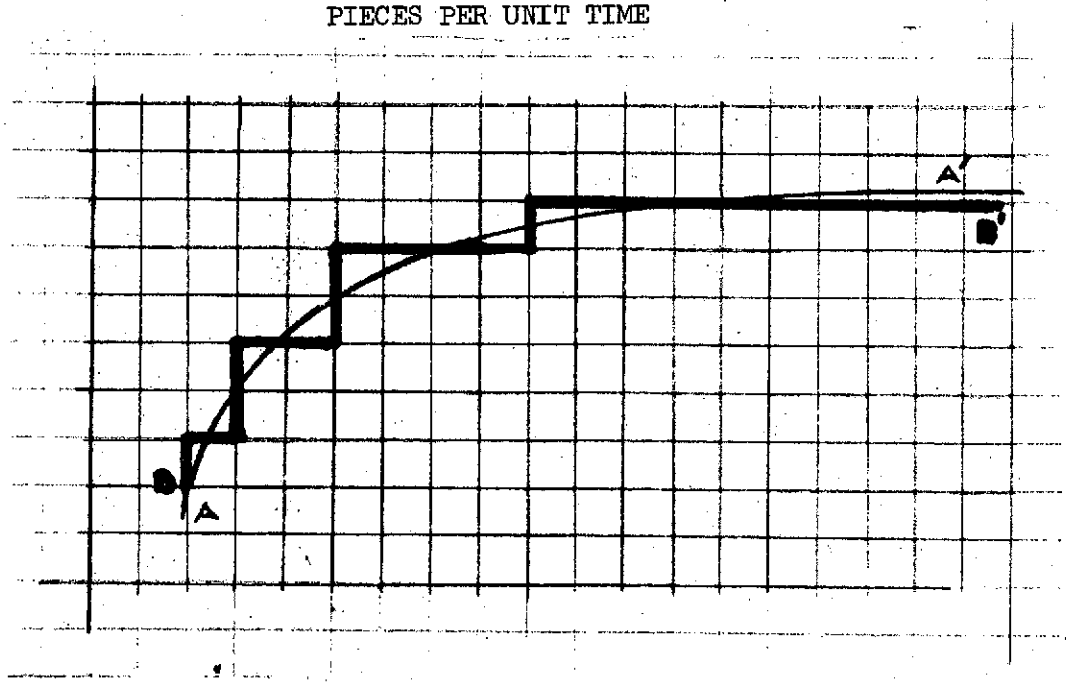
RESOURCE
IN $
OR QUANTITY



PIECES PER UNIT TIME

FIG. No. 2-5A

RESOURCE
IN $
OR QUANTITY



PIECES PER UNIT TIME

APPENDIX A

In general resource requirements expressed in quantative costable units increase with respect to the workload in a curve, conic in form, approximating 1/2 a parabola. The transverse axis is parallel to workload (the abseissa) and it and the vertex are displaced by amounts equivalent to "minimum" requirements associated with the function to be accomplished. Workload can be expressed in many ways; such as manhours, pieces per hour, units per calander unit, etc.

2.2.2.1 Factors Affecting Resource Requirement Curve Shape

In Fig. No. 2-5 curve A-A' respresents a typical aerospace workload/ resource requirements condition for refurbishment, maintenance and reconfiguration. Curve B-B' shown in the same figure would be typical of an infrequently performed or quasi custom type of operation. After inital investment the requirements increased in somewhat a linear fashion as the workload increases.

Curve C-C is more typical of a high production operation, in which initial investment requirements are high but the curve rapidly flattens out as workload increases.

Fig. No. 2-5A shows two typical aerospace curves. Curve B-B' respresents the actual growth in resource requiremnts in a stepped form with respect with workload. This is due to the fact that equipment, facilities and manpower permit certain limited growth in workload without corresponding increases in resource investment. However, as saturation of the growth potential occurs, small increase in workload can cause large increase in resource investment. Once the system definition begines to be firmed up, these "break-points"become important items for off-line analysis and investigation; since these "break-points" and assoicated margins for resource utilization determine the operational constraints of the system for various modes of implementation. Curve A-A' in the same figure (Fig No. 2-5A) shows the average results of B-B'. The average type curve are advantageous in the initial steps of system definition and are also usefull in comparing different systems; particullary, when investigating the influence of workload on resource requirements for varios system configurations and options.

2.2.3 Resource Requirements - General Approach

Of significance in developing the proper curve to reflect the resource system condition with respect to workload, is the vertix displacement A B & C in Figure 2-5 in both the resourced & workload direction. This displacement represents the minimum resource requirement to accomplish any useful work vice the amount of work produced by that resource or set of resources. The key in the preceeding statement is "Mimimum". Initial quantifications of resources per the functional flow blocks previously discussed in Section 2.1.6.1 and the Operational Task Scenarios, Section 2.1.6.3 must always be sized in the direction of the "minimum" requirement to accomplish the task or operational function under study. This, subsequently, establishes the "lower limit" for further analytic efforts which may require manipulation of the resource for increased or increasing workloads. A sub set of this minimum requirement is the evaluation of each resource element to determine its utilization even though a certain set of resources is required to perform an operation, for instance, on a single payload element during a specified period of time the individual resource elements may be under-loaded but necessary. This step helps to initially define the "break-points" discussed in paragraph (2) of Section 2.2.1.1.. Another subtility is, that when considering resource utilization vice <u>elapsed time</u>:

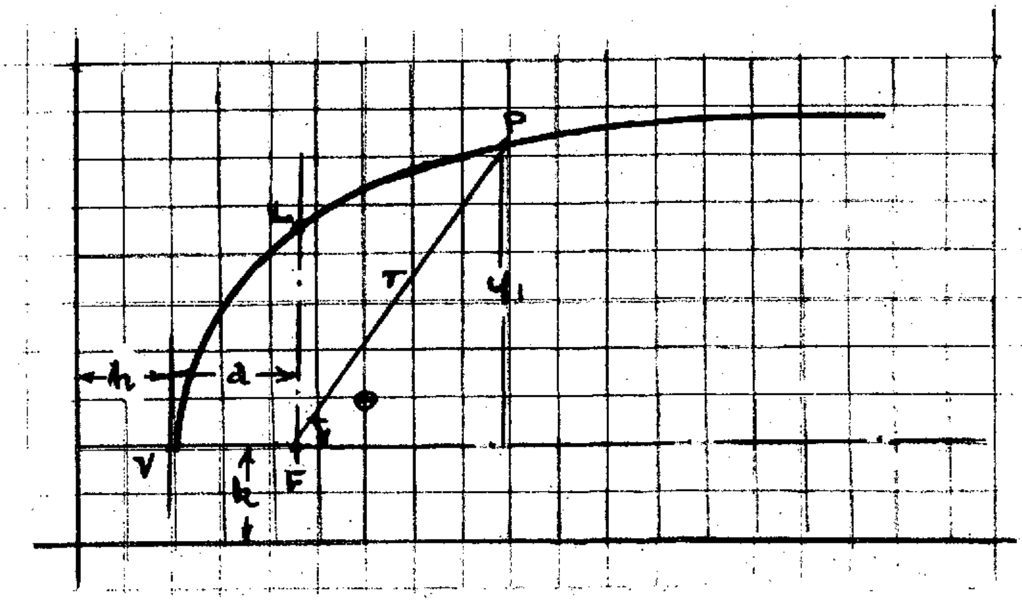
- o For Equipment & Facilities 69% = Full Load
- o For Manpower & Labor 89% = Full Load

The delta percent represent functional losses which must be considered such as: Equipment maintenance downtime, facility servicing, legitimate manpower lost time considerations, etc. These losses will be discussed in depth in subsequent sections of this report (see Section 2.3.6).

We have discussed various "off-line" analytic techniques in Section 2.1.6 and detailed examples will be given in Section 3.0. These are all directed toward to the definition of the "<u>minimum</u>" resource requirements for a given operational function. Figure 2-6 below may help explain the reason for attaching so much important to this concept of developing intially, a <u>minimum</u> resource set for a given function.

FIGURE 2-6

RESOURCE
REQ'MTS
IN $ QUANTITY



PIECES PER UNIT TIME

APPENDIX A

In Fig. No. 2-6 above:

V = the vertix at "h" "k" = Min Resource Requirements (k) to produce (minimum useful) Workload (h)

The expression for this parabola is:

$$4a = \frac{(y - k)^2}{(x - h)}$$

The location of the focus (F) with reference to (r) is:

$$a = \frac{(y - k)^2}{4(x - h)}$$

The lattus rectum (LF) $= \frac{(y - k)^2}{2(x - k)}$

The location of any point (P) along the curve:

$$r = \frac{Y1\ \not{e}}{1\ \not{e}\cos e} \qquad \text{where } e = 1 \text{ for a parabola}$$

Hence, in developing the parabola for resource requirements v.s. Workload, the expression for this curve is dependent on and in summertry with minumum resource requirements and useful workload output (h, k) by definition.

2.2.3.1 Significant Policies Affecting a General Approach

The development of certain policies will effect the sizeing of resource quantities associated with ground processing and maintenance refurbishment of payload modules and subsystems. Theses are the policies that result from the establishment of a philosophy for:

- o Test and Check-out
- o Level of Repair

There are many ways to approach the required philosophy associated with each of the above. However, most require significant definition of flight and ground systems prior to implementation. We will address here only those that apply during conceptual phases which consequently will require modification by more sophisticated methods as the program definition matures.

2.2.3.2 Test and Check-out Philosophy

It is essential that a test and check-out philosophy be developed if the resource requirements generated are to be realistic. As equipment definition improves very discrete test parametrics can be addressed.

In the concept phase certain assumptions must be used. An ordering of priorities is necessary to establish this philosophy. These major considerations might be grouped:

1) Crew Safety
    a) Flight
    b) Ground
2) Safety Flight
    a) Orbiter
    b) Payload
3) Integration Requirements
    a) Payload to Orbiter
    b) Intra Payload
        - Spacelab Module
        - Automatic P/C & 3rd Stage
    c) Experiments to Carrier

4) Mission Performance Requirements

a) Essentiality

- National Security
- National/International Significant
- User/Customer Satisfaction

b) Total Manifest Readiness

c) Criteria for Success

For each potentinal site or sites an allocation of the above requirements must be made in order to evaluate resource requirements. For the "Sample Cases" (See Section 3.0) examined in this study the following philosophy was applied. At the Central Integration Facility:

a) All Spacelab parameters having a bearing on (1) crew safety and (2) safety of flight must be certified.

b) Prime integration testing would concern primarily Spacelab Module(s) integration. Payload to Orbiter integration testing would involve essential physical fit and Orbiter interface continunity, with narrowly limited functional testing.

c) Experinent testing will be limited to compatibility/interference checks and/or verification.

d) Mission requirements testing will be limited Quick Reaction, Rescue and other limited payloads. Total manifest readiness will be determined by analysis of CIF, User, Primary Investigator(s) (PIs) and other test data.

All other testing will be the responsiblity of other functional areas and sites. Another area of test and check-out involves the maintenance and refurbishment area. This is a specialized set of requirements and requires additional allocation of responsibilities.

2.2.3.3 Level of Repair Philosophy:

This might also be called "Maintenance Concept". For defined systems, ther are sophisticated analytic methods of determining the cost effective Level of Repair (LOR). These are defined for military aircraft programs in MIL STD 1390 (Navy) and AFLCM/AFSCM 800-4 (Air Force). Basically the technique involves evaluating the acquisition cost of the component, the resource and operational cost of maintenance to determine decisions as to whether the item should be maintained and at what level is it most cost effective to do this activity.

In initial system concept analysis; since, much of the required data to perform an LOR type of analysis is unknown. It is necessary to establish certain "ground rules". If these rules are applied universally then analytic proceedures will provide in the simulation model an "apple-to-apple" comparisons, when considerering various modes for system implementation. In the "sample case" examination (Section 3.0) which follows. The following ground rule LOR or "Maintenance Concept" has been applied:

a) No major maintenance is performed on the CIF payload processing/ integration line.

b) All CIF process-line maintenance while limited to off main-line activity is further limited to

- Top level diagnosisis
- Remove & replace actions
- Align, adjust, recalibrate actions

c) The Central Integration Facility will have adequate here I & II maintenance shop capability for the primary task of spacelab integration. Certain Level II shops may be located elsewhere; however, the processing of Level II maintenance work, regardless of location, will not degrade P/L processing time.

d) AGE/GSE required for the support of the P/L integration process will be maintained, calibrated, refurbished, etc. in an off-line manner and will not affect the main line P/L processing time.

e) Industrial or Militar/Industrial Level III (depot) maintenance requirements are recognized but not defined in this analysis. For the purpose of this study, this capability is assumed to be adequate to support the expected workload.

f) Adequate spare parts will be available to support the CIF processing requirements

g) Existing installation, facilities and capabilities will be used where ever possible.

2.2.4 Facility Requirements - General Approach

The lead time associated with the acquisition, design, construction or modification and the activation of facilities imposes in most aerospace systems a strong requirement for early definition. In addition, the high intital cost associate with this resource further imposes the requirement for rather rigorious analysis. The details associated with requirement are some evolutionary in that the level of detail associated with the requirement increases for various phases of the program. The detail evolution is as follows:

APPENDIX A

Program Phase	Requriement Data	Purpose
a) Concept Definition	Gross Functional needs	Trade studies - System Selection criteria
b) System Definition	Refined Functional Requirements - Screen against existing assets	Scope total requirements - New Construction modification of existing structures
	Integrate requirements for maximum utilization	- Establish buget requirements
c) System Implementation Program Definition	Scale drawings & models Detail definition of utility and facility service requirements	Furnish requirements to A & E design contractor Provide cognizant activities with timely activation data for effective implementation
	Establish activation schedules consistant with program	
d) Operational Program	Review design data for requirements compatibility	Contract new construction &/or facility modification
	Develop GSE interface data for equipment installation	Install and verify equipment - Perform requirements demonstrations to assure System performance
	Review and evaluate construction progress	Implement operation

The present level of STS definition permits significant analysis primarily addressed to the first two categories above (a & b).

In order to assist in scoping facility requirements the data in Tabel 2-5 is presented. This data summarizes planning data used for scoping military aircraft requirements. While not directly applicable to the STS program it does furnish a comparative example of analogous facility requirements. This data was developed by Grumman during the NAFAC study for the Naval Facilities Engineering Center and was the result of in depth analysis and evaluations conducted at seven air-stations having significantly differing mission requirements.

TABLE 2-5

(NAVY) AEROSPACE FACILITY REQUIREMENTS

SUMMARY

A/C Shop	Workload Manpower	Sq. Feet Required	Analogous to STS (Level II)
Power Plts	10 - 14 150 - 170	9,200 56,100	RCS System Rocket Eng.
Airframe	0 - 20 160 - 180	5,500 21,000	P/L Structures Mech. System
Avionics	0 - 50 160 - 180	20,000 64,500	Astrionics
Armament	0 - 2 39 - 48	4,500 10,500	Pyrc's, Pyro. System
GSE	0 - 10 66 - 70	3,050 21,200	GSE

2.2.4.1 Large Equipments and Installations

The requirements associated with large equipment, installations and assemblies are dictated by the size of these elements. In addition allowances must be made for the handling and installation of these. Such things as turning radius, hook heights, door clearance cannot be neglected. An example of this type of requriement is given in the "sample cases" discussed in Section 3.0 of this report. In the case examined, the S.U. simulator, the probable size of the simulator and the EM/Pallet assembly dictate the facility requirements .

Parameters which must be established for this type of a facility requirement include,

- o Area - in square feet
- o Overhaul limits - high bay requirements
- o Floor loading - static and dynamic
- o Overhead Crane - capacity & hook - height
- o Cleaniness Requirements

Requirements for this type of facility at same point in evolution are enhanced by scale physical models to assure adequate consideration has been made for the associated handling and movement parameters.

2.2.4.2 Level III, Maintenance Shops

The depot shop requirements are perhaps the most difficult to quantify. The shops are similar to and sometimes identical with aerospace contractors industrial facilities. Rather rigorous studies must be made for these requirements to determine a cost effective approach. Whether it is more cost effective to maintain a production/ refurbishment line at a contractors plant after the production phase is complete or should the Government establish a dedicated facility and capability to accomplish this function must be determined. The LOR discussed in 2.2.3.2 is an applicable technique for this type of an effort. Because this is such a specialized facility requirement it beyond the scope of this study to cover it any greater detail. However, such a requirement must eventuall be defined as part of the total STS program.

2.2.4.3 Level II, Maintenance Shops

These shops perform off-line maintenance and refurbishment of payload elements. They are usually located adjacent to the main processing line, but need not be located coincident with process (P/L integration) line. The scope of work in this shops is limited to subsystem repair down to lowest shop replacement unit (SRU). These would include subsystem modules, and except in specialized cased, do not include component repair.

2.2.4.4 Mechanical/Structural, Level II Shops

These shops provide the capability to perform machine shop and sheet metal repair functions. Hence, equipment located in this type of a facility would include: lathes, drill press, millers, sheet metal brakes, welding booths, finishing equipment and x-ray, zyglow, magna-flux test equipment.

Parameter which must be identified to define this type of facility include:

- o Area - in square feet
- o Floor Loading - Static and dynamic
- o Overhead crane - capacity & hook - height
- o Electric Power - Voltages total connected load, phasing
- o Ventilation Requirements - Welding finishing and x-ray inspection areas.

2.2.4.5 Pressures, Fluids & Cryogenic, Level II Shops

These shops are the location where maintenance is performed on hydraulic, ECLS, servo and cyrogenic sub-systems. The cryogenic requirement is the most expensive installation and is somewhat specialized and separated from the others depending on many factors. Such as the gases involved, required storage capacities, whether the gas is compressed at the site or delivered in cryogenic state. This requirement is a prime candidate for off-line analysis to generate creditable information. The pressures and fluids type of shop usually has hydraulic test benches, pipe repair equipment, brazing units, and cleaning stations installed at the shop.

Requirements definition must include:

- o Area - in square feet
- o Electric Power - Voltage & connected load
- o Ventilation Requirements - cleaning station
- o Safety Requirements - safety cages, pressure vents, alarm systems
- o Cleaniness - for servo & hydraulic pump repair stations
- o Lighting - Lumen required at bench height for small assembly repair station.
- o Gasses & Fluids - consumable storage or facility services
- o Drains - To remove spills

2.2.4.6 Astrionic Shops, Level II

These shos are used to support electronic and electric subsystems. These include: communication, navigation and on-board automatic equipment. Floor loading in these shops are equivalent to light industrial loads.

Definition of requirements for these shops must include:

- o Area - in square feet
- o Cleaniness - for module repair areas
- o Electric Power - Voltages, services (D.C., 60 & 400 Hz) connected load and requlation requirements.

APPENDIX A

- Air Conditioning Requirements - to maintain constant temp. and humidity
- Lighting - Lumen required at bench height
- EMC/EMI - grounding (power & instrument) Shielding if required

2.3 Ground Support Equipment - General Approach

In defining Ground Support Equipment at this stage of vehicle definition is done almost exclusively by comparison of existing or known vehicles having similar systems. Here, past experience on a wide variety of Aerospace vehicles is essential.

2.3.1 Functional Sets

The term Functional Set is used to describe all the items of equipment required to perform a given function rather than identifying individual bits and pieces that make up the set.

Having a functional set defined allows the visibility to look at total program and identify requirements when a given function is repeated in various parts of its life cycle.

2.3.2 Handling, Mechanical/Structural Equipment

As a general rule the least complex and lowest life cycle cost items of GSE, into this category falls slings, spreader bars, attach fittings access stands operational jigs and other items of this nature.

These items generally require little attention during their operational life.

2.3.3 Transportation Equipment

In this category we find items such as transporters covers and tie down kits. Although, for the most part, these items fall into the low-moderate cost range both for procurement and operations. However, in cases where services are demanded by the vehicle, such

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as pressure and temperature maintenance environmental control to tight tolerances, this cost can become very significant.

For this reason, very early recognition should be made during vehicle design, and every effort made to eliminate requirements of this nature.

2.3.4 Pressure, Fluid & Cryo Equipment

Equipment in this group, with the exception of cryo equipment tend to fall in the high-moderate cost bracket for both procurement and operations, again however, the placing of unrealistic requirement on operational parameters can drive the cost for both procurement and operation "out of sight".

Cryo equipment, by its very nature is in the very high cost range both in initial procurement and its day by day operations. The key to cost reduction is making maximum use of commonality with all program elements.

2.3.5 Astrionic Equipment

The sophistication of present and planned space vehicles with the attendant desire for automation has driven this equipment to the very high cost for both acquisition and operations, with software costs approaching hardware costs in some instances.

The apparent method for cost reduction in this area would again be institutioning astrionic support equipment.

2.3.6 Manpower Requirements - General Approach

In this section we will define methodology to be used in establishing manpower requirements for the ground turnaround operations of the Spacelag. Also, ground rules and assumptions will be listed.

2.3.6.1 Minimum Crew Sizing

In establishing the crew required to perform the various tasks within the functions, the following ground rules will be applied.

- Experiment peculiar requirements will not be included.
- "On line" maintenance limited to remove and replace.
- One man year equals 1848 man hours. This Manpower Conversion Factor (MCF) represents the following:

  80 hours vacation
  11 paid holidays
  2 hours voting time
  40 hours sick/personal time
  22 hours misc.

This MCF will be used to size the crew based on traffic requirements.

2.3.6.2 Influence of Learning and Effectiveness Factors

Although primarily used in cost determination for recurring hardware production, the learning curve technique can be useful in predicting cost, in manhours, for any repetetive operation that is performed by a worker or groups of workers. Operations which are strictly machine functions obviously do not fall in this category.

Since the turnaround functions on the Space Lab are mainly repetetive in nature, we will apply the learning curve techniques in establishing the crew size.

Experience and past analyses have shown that operational learning closely follows at 90% curve to the 50% point, beyond this point, very little increase in operating efficiency is gained. The formula used for this time required is:

$$Tu = f\left[n^{1-x} - (n-1)^{1-x}\right]$$

where

Tu = time in manhours

f = first unit time

n = number of times function performed

x = 0.152 for 90% curve

There are other factors which influence manpower loading which we call effectiveness factors. These factors cost time, and must be accounted for. These "lost time" items include:

- Coffee Breaks
- Wait time (tool crib stock room, etc)
- Equipment anomalies
- Personal requirements

While these items seem to be quite obvious, they are often overlooked in early planning, resulting in repeated schedule "adjustments". This lost time varies widely, depending on function, working conditions, and worker motivation.

In industry, the effectiveness factor for factory labor used in time and motion study is as follows: 'The standard time for a job will

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be 130/100 of the amount of time nexessary to accomplish a unit of work, using a given method under given conditions, by a worker who possesses the sufficient skill to do the job properly ...'.

This industry factor is based on an average worker under average factory conditions. On the Space Lab we will assume a specially highly trained technician well motivated and working under excellent working conditions. Assuming all the above, and based on experience at both factory and field sites we will use an effectiveness factor of 111/100 for manpower determination.

2.3.6.3 Influence of Training Requirements on Manpower Planning

As a prerequisite to establishing a functional operational team aimed at the lowest operational cost in terms of manpower expended, we will assume a stringent training program for all skills and disciplines prior to first operational turnaround, this training will include both "classroom" training and on the job training.

Following this assumption, and recognizing that the Space Lab Program will require operational turnaround functions be performed on a relatively steady and frequent basis, it is felt that training refresher courses will not be required, skills will be retained by doing. Also it may be noted that attrition rate on programs of this nature is extremely low (less than 1% during active LM operations) so that training of new employees can be absorbed with no significant impact.

3.0 SAMPLE CASES

In order to best demonstrate the techniques involved in quantifying resource requirements, examples based on the existing OPS Model were selected. Further, available study resource would not permit examination of every significant function. These examples are termed Sample Cases.

3.1 SAMPLE CASE NO. 1

The example we will explore in this Sample Case involves those functions concerned with the checkout between the Support Unit Simulator and the EM/PA. The interfaces, as defined in the MSFC Simulator Requirements Document of 10 October 1973 include:

- Mechanical attachment
- Power distribution
- Data management
- Caution and warning
- Altitude control
- Navigation
- Communication

Those functions to be supplied by Ground Support Equipment are power, thermal and environmental control.

3.1.1 Functional Flow and Task Narrative

Figure 3.1-1 depicts the Level II Functional Flow we will use in this example. We assume, for this Sample Case that the EM/PA stand is not compatible with the SU simulator mating fixture.

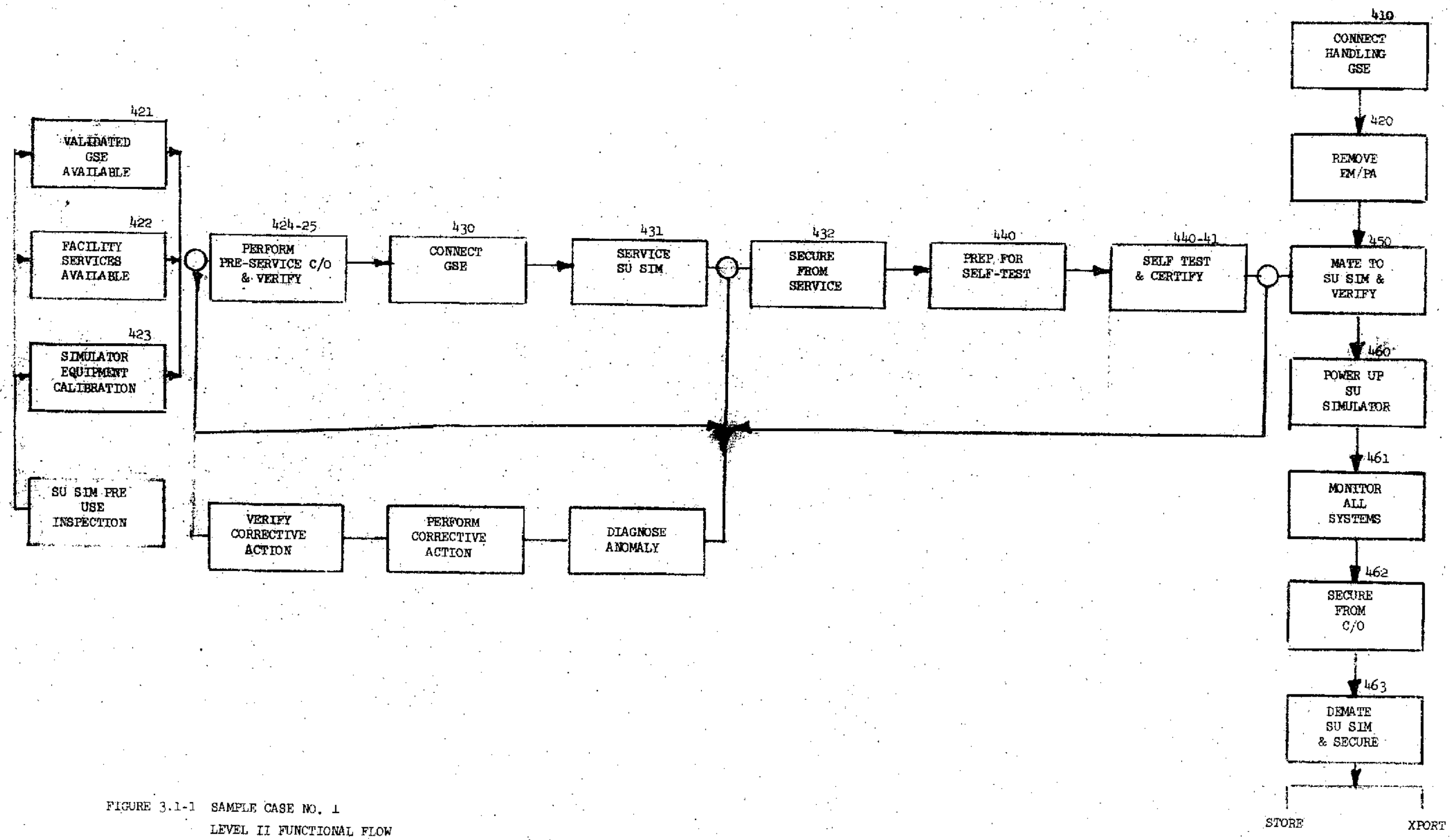

FIGURE 3.1-1 SAMPLE CASE NO. 1
LEVEL II FUNCTIONAL FLOW

Pg - 46

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(A)
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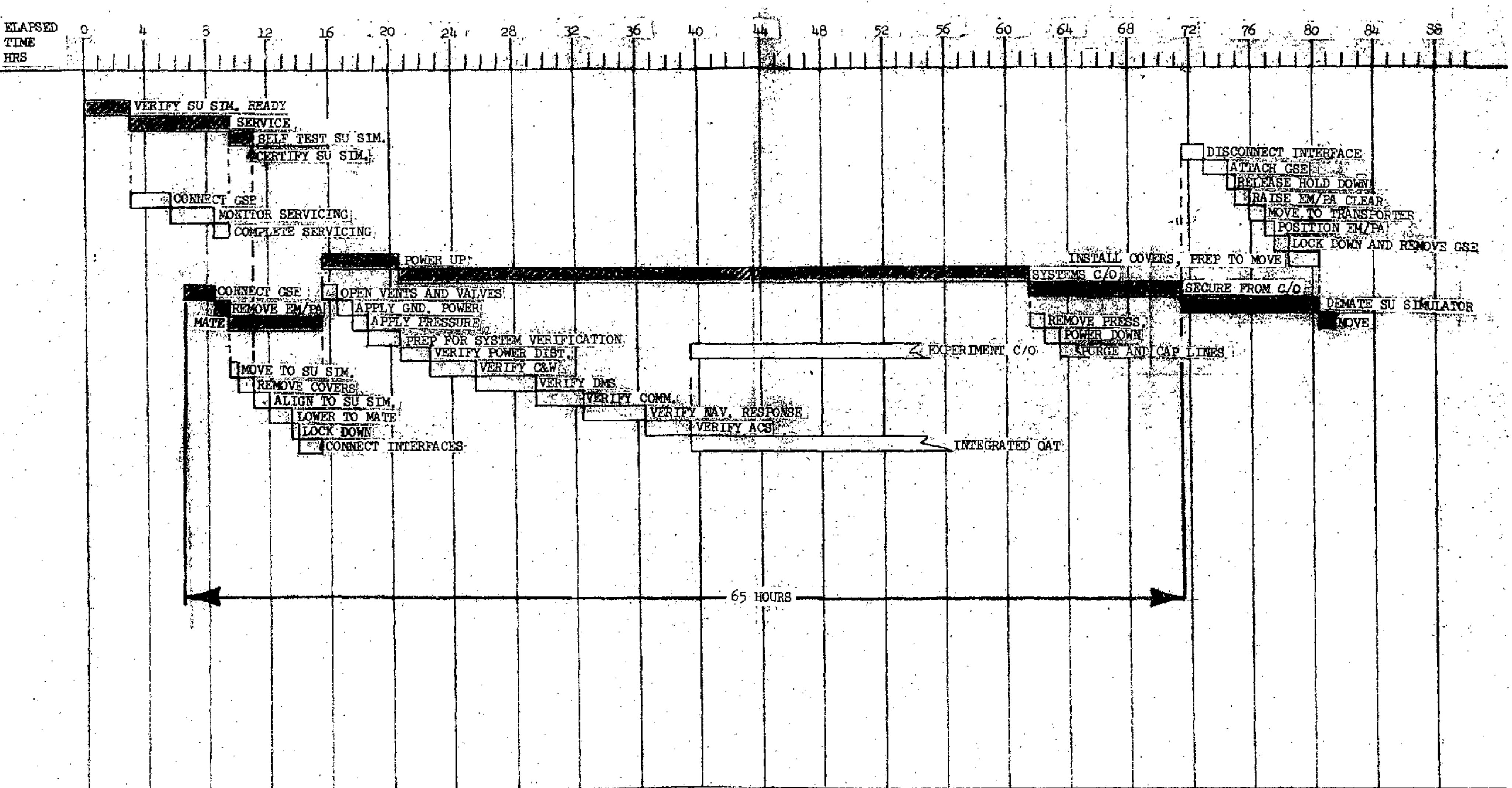

FIGURE 3.1-2 SAMPLE CASE NO. 1
TIME LINE

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The associated time line, Figure 3.1-2 was created using the Level 0 times from the OPS model, distribution to Level II was made to create the sub-flow within the basic function.

In order to accurately compare Sample Case No. 1 with Sample Case No. 2 in the following section, we will begin the Task Narrative six and a half hours into the time line flow.

The first task is to attach the lifting and handling GSE to the mated EM/PA; the hoisting sling will be attached to an overhead crane through the auxiliary crane control; slack taken up by the crane and TBD pounds applied using the aux. crane control. The EM/PA will be disconnected from its tand and moved to the SU simulator mating position. In parallel with this activity the SU simulator will be certified ready.

With the EM/PA in position, all covers, plugs and caps, will be removed. The EM/PA will be aligned with the SU simulator, lowered to mate and hard mated. All interfaces required for combined systems verification will be made, these interfaces will include hook-up to the required GSE.

Power up procedures are then instituted along with the ground equipment supplied thermal and environmental control. The integrated SU sim/EM/PA is prepared for system verification checkout sequentially followed by an integrated "Overall Test". During the OAT, experiments will be powered up to verify compatibility between all elements.

Upon successful verification of the integrated systems, pressurer and power are removed, lines and ducts are surged and capped.

Mean time, as shown in Figure 3.1-2, to accomplish these functions, is 65 hours. The off-line simulation of these functions (see Task 2) which introduces time variables, indicates that actual elapsed time may run from 65 to 77 hours, or an increase of 18.4%.

It must be noted that an amololy may occur at any point in the flow which could require diagnosis and corrective action increasing the flow time dramatically. This diagnosis and repair loop can easily be introduced to the referenced off-line routine.

3.1.2 SU Simulator Resource Breakout

In establishing resource requirements for the functions in Sample Case No. 1 two items are of particular significance. The first item, traffic date build must either be geared to the earning curve addressed in Sect. 2.3.6.2, or a penalty in early excess manpower will be incurred. If we examine the unit time formula $Tu = f(n^{1-x} - (n-1)^{1-x})$ and use 100 for n, solving for f or first unit time $f = \frac{Tu}{(100^{.848} - 99^{.848})}$ we find that $f = \frac{Tu}{.5}$ or the first unit will take twice as long to process, in manhours then the 100th unit. Therefore, to perform the function either time or manpower must be adjusted.

The second item, maximum traffic rate impacts all resources if such rate requires parallel action on two or more vehicles. It can easily be seen that such parallel operations could result in additional facilities, manpower and GSE.

Therefore the following assumption has been made:

a) Traffic at the CIF will never exceed 20 vehicles each year

b) These 20 flights will be evenly spaced in a given year.

3.1.2.1 Functional Sets, Sample Case No. 1

Referring to the time line, Figure 3.1-2 the first task, that of positioning the EM/PA and mating the SU simulator requires the following: (1) Transporter Functional Set consisting of the EM/PA Transporter frame, mobilizer and associated covers. (2) Handling Functional Set consisting of slings, spreader bars and hydroset. (3) Alignment Fixture Functional Set consisting of gages and sights to properly align the EM/PA and the SU Simulator. These functional sets will be utilized for nine elapsed hours.

The second set of functions on the time line involves preparing for and executing an Over All Test (OAT) of the mated SU simulator; the functional sets required are: (4) Ground Power Functional Set consisting of ground power supply controls and interfacing cables. (5) Checkout Station Functional Set consisting of an RF front end and formatter, mini computer, modular CRT displays up link command module and all associated cables and antenna hats (6) Heat Transfer System Functional Set consisting of coolant storage tanks, refrigeration unit, trim control unit and associated lines and hoses. (7) Life Support Unit, Functional Set consisting of GO_2/ GN_2 source, air conditioning unit, flow control panel and associated lines and ducts. (8) Access Functional Set consisting of various stands and steps enabling access to the mated vehicles. (9) Experiment Peculiar Functional Set consisting of any peculiar equipment required for experiments. Under certain conditions one additional set may be required. (10) Zero "G" Simulator Functional Set consisting of a support frame cables, pulleys, counter-balances and springs to simulate a zero "G" condition for certain space moving experiments. These functional sets will be utilized for fifty eight and one-half elapsed hours.

3.1.2.2 Facility Requirement Sample Case No. 1

In assessing the facility requirements of Sample Case No.1, it was determined we would require an open bay of 4000 square feet in area, equipt as follows 35 ton crane, hook height of 35 feet, air conditioned, filtered air to maintain a 1,000,000 cleanliness level, shop air regulated and GN_2, 20V, 220/440V 60Hz service. Sized in this manner the space would support EM/PA placement and SU simulator mating. Utilization of this facility for Sample Case No.1 would be sixty-five elapsed hours per unit flow.

3.1.2.3 Manpower Requirements Sample Case No. 1

The Ground Operations Engineering Analysis (GOEA) method of detailed examination of each action which must be made to accomplish a given function is employed in determining the direct technician requirement needed to perform these actions. This analysis there, includes all of the elements of the function being examined. Once this direct labor is identified, percentages are used, based on past experience, to determine other supporting manpower. This support includes engineering administration, production control and publications.

APPENDIX A

Again entering the time line Figure 3.1-2 the function of moving the EM/PA to the mate position was examined and yielded the following:

DIRECT	SUPPORT
4 Mech./Struct Tech	1 Crane Oper.
1 QC	1 Mech. Eng.
1 Safety	

Elapsed time is 4.5 hours (36 manhours)

For interface hook up we will add:

DIRECT

2 Avionic Techs

2 Fluid and gas Techs

1 Additional QC

Elapsed time is 1.5 hours (19.5 manhours)

The next function, that of prepping and running the mated SU simulator OAT was next examined and the following crew was defined:

DIRECT	SUPPORT
2 Mech/Struct Techs	3 Avionic Eng.
4 Fluid and Gas Techs	2 Fluids and Gas Eng.
5 Avionic Techs	
2 QC	
1 Safety	

Elapsed time, including secure from C/O equals 58.5 hours (1111.5 manhours)

APPENDIX A

Since the flow used in the sample case was entirely sequential, no parallel operation, we can define a single crew for the functions examined.

DIRECT	SUPPORT
4 Mech/Struct Techs	1 Mech Eng.
4 Fluid and Gas Techs	3 Avionic Eng.
5 Avionic Techs	2 Fluids and Gas Eng.
2 QC	1 Crane Op.
1 Safety	

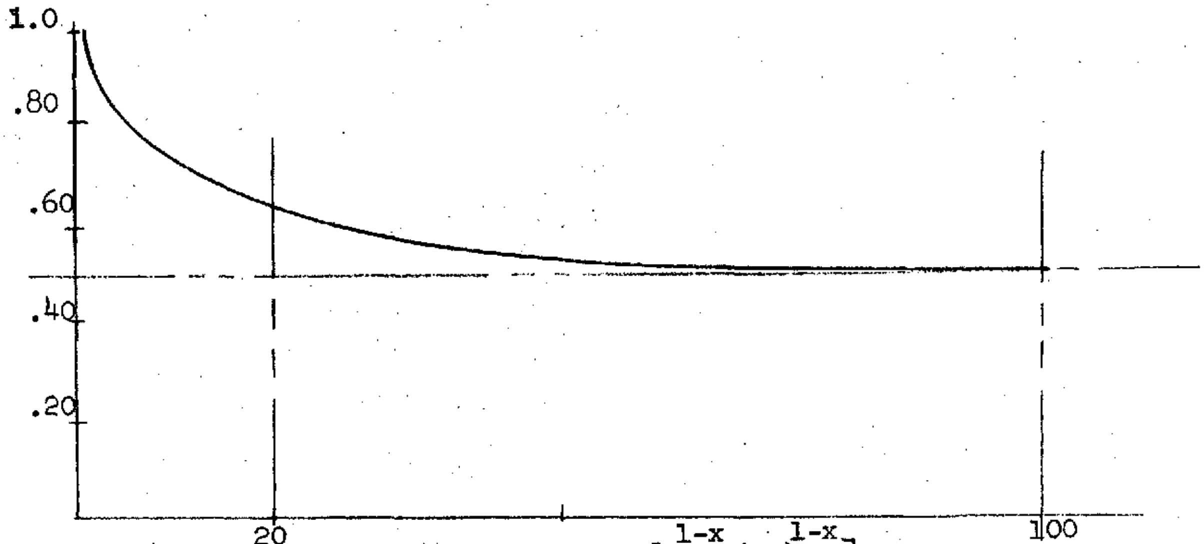
Total elapsed time 65 hours (1167 manhours)

Taking the effectiveness factor from Section 2.3.6.2, however, indicates the actual time will increase to 1295 manhours (1.11 x 1167).

These manhours, arrived at by simple mathmatics are now played against the simulation run from Task 2 which applies a time distribution function. From this run, we find that the average elapsed time is not the 65 hours of mean time initially used, but 77 hours. This increase of elapsed hours gives us an additional factor further increasing our expended manpower to 1.18 x 1295 or 1528 manhours expended for each turnaround.

Using the 10 flight maximum through the CIF shows that a total of 30,560 manhours will be expended to process these 20 units through the functional block examined in this Sample Case. With the basic crew we have available 42,504 manhours.

In this Sample Case, it was assumed that the mean times used represented a mature flow, if we now back up the learning curve to the first year of operation, and assume the same 20 flight rate, we find that the expended manhours increased to 54,379 manhours thereby exceeding our basic curve capacity. Figure 3.1-3 graphically portrays this increase.

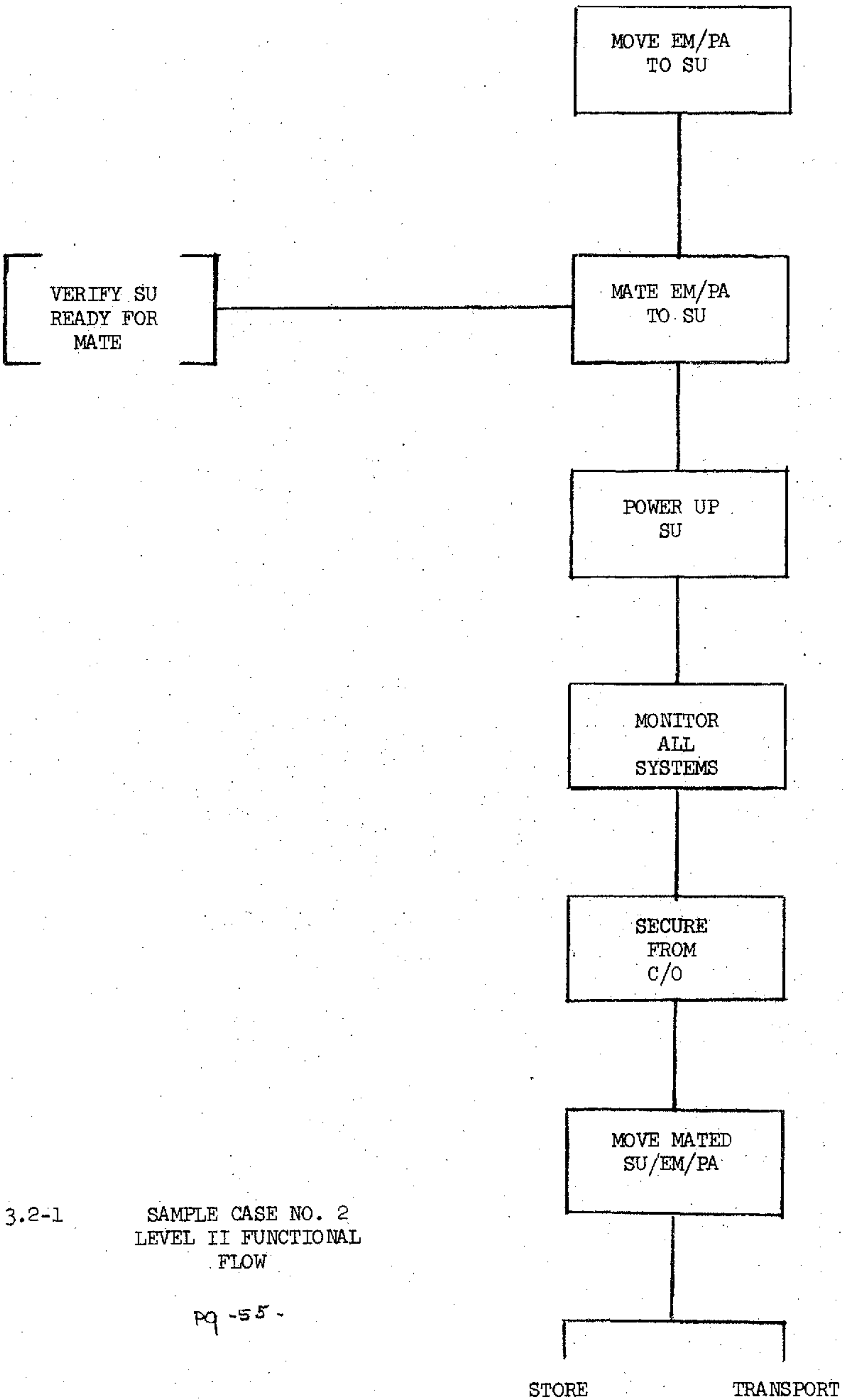


$$\text{UNIT TIME} = \text{FIRST UNIT TIME} \times \left[n^{1-x} - (n-1)^{1-x} \right]$$

FIGURE 3.1-3

3.2 SAMPLE CASE NO. 2

In this example, we will explore those functions involved in the mating and checkout of the Support Unit itself with the EM/PA. The interfaces noted on Section 3.1 are the same. We will assume G.S.E. will provide the ground power, therman and environmental control. The thermal and environmental controls and distribution will, however, be through the flight system.



:GURE 3.2-1 SAMPLE CASE NO. 2
LEVEL II FUNCTIONAL
FLOW

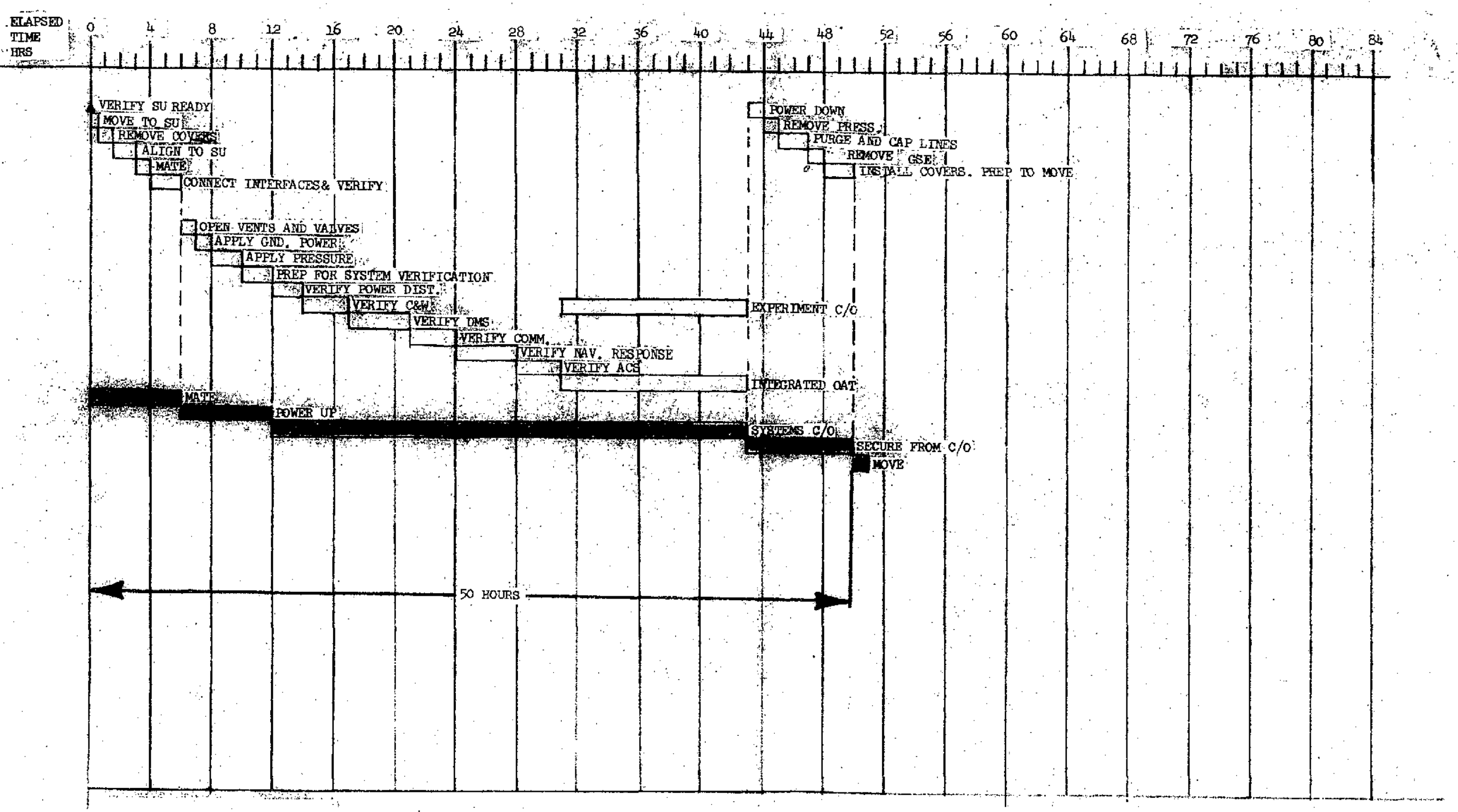


FIGURE 3.2-2 SAMPLE CASE NO.2
TIME LINE

Fq -56·

3.2.1 Functional Flow and Task Narrative

Figure 3.2-1 depicts the Level II Functional Flow to be used in this example. In this Sample Case, we have assumed that the EM/PA stand/transport, is compatible with the SU mating fixture. Figure 3.2-2, the associated time line was generated by examining the activities required and assessing the time past on past experience with similar systems.

The first task in this ample is moving the EM/PA to the SU mating stand, it is assumed that the EM/PA stand/transporter is capable of being towed into position so no slings are required. When in position, all covers, plugs and caps will be removed, the EM/PA will be aligned with the SU and all interfaces will be connected.

Power up procedures are identical to Sample Case No. 1 as is the OAT. One additional function will be performed, that being a leak check between the SU and the EM/PA.

Following the secure from C/O, the mated SU/EM/PA will be prep to ship or enter a ready for issue storage.

As with Sample Case No. 1 anomalies may occur at any point in the flow resulting in down time for diagnoses and repair.

3.2.2 SU Resource Breakout

Resource requirements for the functions in Sample Case No. 2 are subject to the same problems noted in Section 3.1.2. The same assumptions will be made.

3.2.2.1 Functional Sets, Sample Case No. 2

The functional sets for Sample Case No. 2 are the same as those listed in Section 3.1.2.1 with two exceptions. These exceptions are 1) no handling functional set is required and 2) added to that equipment used in the OAT; (11) Cabin Leak Detector Functional Set consisting of a leak detection system and associated ducts and hoses.

3.2.2.2 Facility Requirement Sample Case No. 2

Same as Sample Case No. 1.

3.2.2.3 Manpower Requirements Sample Case No. 2

The same methodology used in Section 3.1.2.3 has been applied to this sample with the following crews defined:

Moving EM/PA to mating position

DIRECT	SUPPORT
3 Mech/Struct. Techs	1 Tug Oper.
1 QC	1 Mech Eng.
1 Safety	

Elapsed time 4 hours (28 manhours)

For interface hook up we will add:

DIRECT	SUPPORT
2 Avionics Techs	1 Fluids & Gas Eng.
3 Fluid and Gas Techs	
1 QC	

Elapsed time 2 hours (26 manhours)

For the functions for prepping for and running the OAT the following personnel are required:

DIRECT	SUPPORT
2 Mech/Struct Techs	3 Avionic Eng
5 Fluid and Gas Techs	3 Fluid and Gas Eng.
5 Avionics Techs	
3 QC	
1 Safety	

Elapsed time, including secure from C/O equals 44 hours. (968 manhours)

As with Sample Case No. 1, we can now define our basic crew:

DIRECT	SUPPORT
3 Mech/Struct Techs	1 Mech Eng.
5 Fluid and Gas Techs	3 Avionic Eng.
5 Avionic Techs	3 Fluid and Gas Eng.
3 QC	1 Tug Operator
1 Safety	

Total elapsed time 50 hours (1022 manhours)

Again, from Section 2.3.6.2 the effectiveness factor increases the manpower expenditure to (1022) x (1.11) 1134 manhours.

From Task 2, we find that the mean time, using the time distribution functions becomes 55 hours of elapsed time, or a 10% increase. Utilizing this factor our actual expenditure becomes (1134) (1.10) 1247 manhours for each turnaround. For the 20/year turnaround of this mature flow, we will expend 24, 940 manhours out of an available 46,200 manhours.

Backing up the learning curve, as in Sample Case No. 1, we find that to accomplish 20 cycles in the first year, we would expend 37,862 manhours which is within our available manpower resource.

3.3 COMMENTS AND RECOMMENDATIONS

While examining the functions in Sample Case No. 1, and maintaining the concept of a Central Integration Facility, it was difficult to understand any real operational gains to be made utilizing an extremely expensive and complicated simulator for pre-SU mate verification. With the present limited visibility, we would recommend deletion of this simulator from the CIF flow. Upon additional study, this recommendation could change.

It is further recommended that waterfall time lines be developed and tiered to visually spot possible pitfalls in the flow. Also, off-line simulations, with built-in time variations should be developed for all critical functions.

OPS MODEL STUDY

APPENDIX B

CREATION OF TIME DISTRIBUTIONS

REPORT NO. SU OPS-RP-73-0002B

PREPARED FOR THE

GEORGE C. MARSHALL SPACE FLIGHT CENTER
HUNTSVILLE, ALABAMA

CONTRACT NUMBER

NAS 8-30302

PREPARED BY

GRUMMAN AEROSPACE CORPORATION
BETHPAGE, L. I., N. Y.

DATE: 29 March 1974

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OPS MODEL STUDY

APPENDIX B

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1.0 STUDY TASK

In this task, time distributions are created and expressed as mean values, then times are then modified by appropriate density distribution functions to more accurately reflect a "real world" situation.

2.0 INTRODUCTION

In the course of developing the Shuttle payload ground operations simulation model, NASA has introduced into the computer program processing "times" for various ground operations and activities. These "times" for the most part are "first-cut" estimates based upon NASA's past experience. They must still be refined to the point where normal expected variations in the operations and activities are considered.

This refinement of processing "times" will consist in a detail examination of the activity to be performed and breaking down the overall operation into more discrete, easily quantified tasks. Task "times" for these simple more basic tasks will be developed along with the possible variation in time that would normally be expected to occur. These "times" are then modified by appropriate probability distribution functions.

3.0 DISCUSSION

The detailed Level II flow for the SU simulation process, developed in Task - 1 SAMPLE CASE 1 was further expanded in this task to include probability distribution functions. An off-line, level - 2 GPSS simulation model was developed in order to evaluate this specific activity. Three basic probability distribution functions were used in the model to modify the specified mean values (fig. 1).

The log-normal distribution, with a mean value of one (1) was chosen to modify those activities which consisted of basically a repair function. This distribution permitted repair times to vary between zero (0) and five (5) times the specified mean value.

The exponential distribution with a mean value of one (1) was chosen to modify those activities which consisted of basically a troubleshooting and checkout function. This distribution permitted troubleshooting times anywhere from zero (0) to as much as ten (1) times the specified mean value.

The normal distribution was chosen to modify those activities which did not have as large a variation in processing times as those activities previously mentioned. Examples of such activities are transporting, connecting cables, disassembly, etc.

The incorporation of these probability distributions into the model resulted in an overall activity time of 77.1 hours for the SU simulator process. This represents almost a 20% increase over the allocated processing time of 65 hours. Figure 2 presents the distribution of the activity times for the overall SU simulation process.

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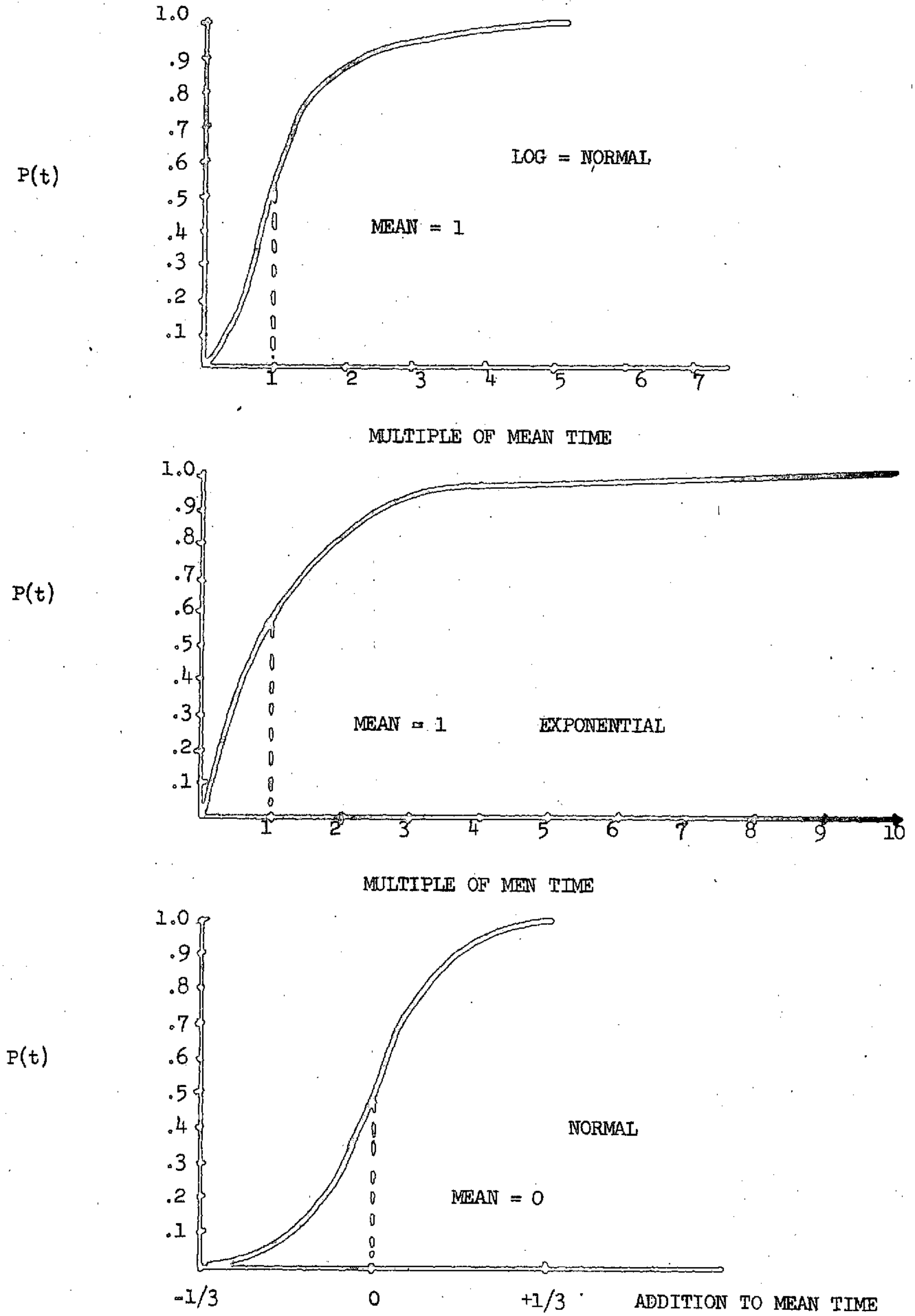

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FIGURE (1)

CUMULATIVE PROBABILITY DISTRIBUTIONS

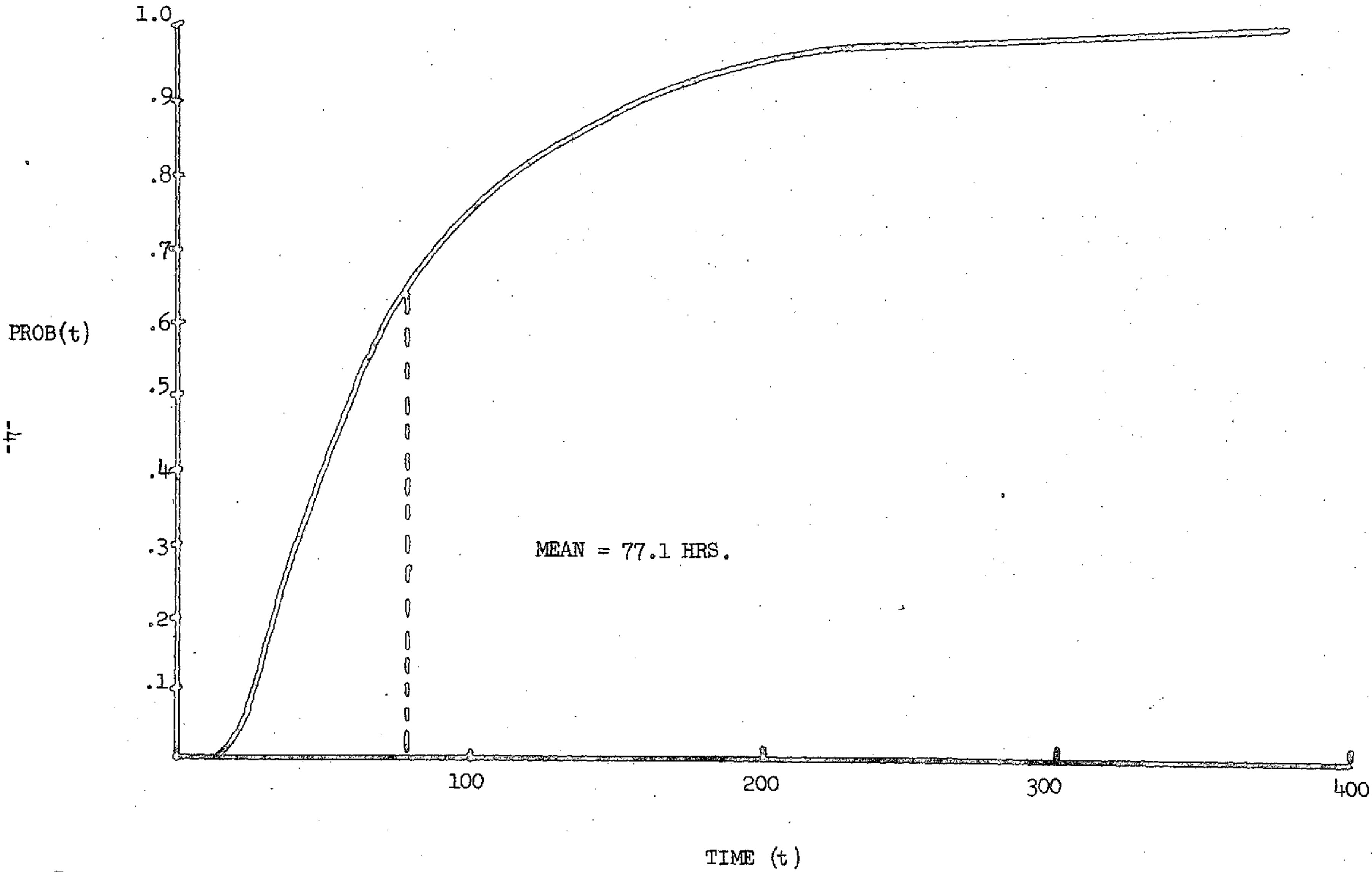

FIGURE (2)

CUMULATIVE PROBABILITY DISTRIBUTION
FOR
OVERALL S. U. SIMULATION PROCESS
(SAMPLE CASE -1)

3.0 DISCUSSION (Continued)

Enclosure (1) contains the GPSS simulation model for the SU simulation process (Sample Case 1). The model was exercised for a ten (10) year period in order to achieve a satisfactory sample size. Two separate runs are included to highlight the difference between simulations with and without modifying probability distributions. The model was constructed such that 10 clock units equal 1 hour. Table 1 contains a list of GPSS entities and their association with SU simulation process.

The detailed Level II flow for the SU Simulation Process Sample Case - 2 was also simulated as part of Task No. 2. The same three probability distributions, previously mentioned, were applied in the same manner as before.

The incorporation of these distributions into this flow resulted in an overall activity time of 55 hours for this alternate process. This represents approximately a 10% increase over the processing time if no randomness was considered, i.e. 50 hours. Figure 3 presents the distribution of the activity times for this alternate process.

Enclosure (2) contains the GPSS simulation model for this alternate process (Sample Case 2).

TABLE 1

GPSS Entities used in SU Simulation Model

STORAGE	1	The SU Simulator
QUEUE	1	The waiting line for the SU Simulator
TABLE	1	Presents the time it takes for a payload to pass through the system
TABLE	2	Presents the time that a payload with a discrepancy remains in the system
TABLE	3	Presents the time that the SU Simulator is being tied-up, including servicing

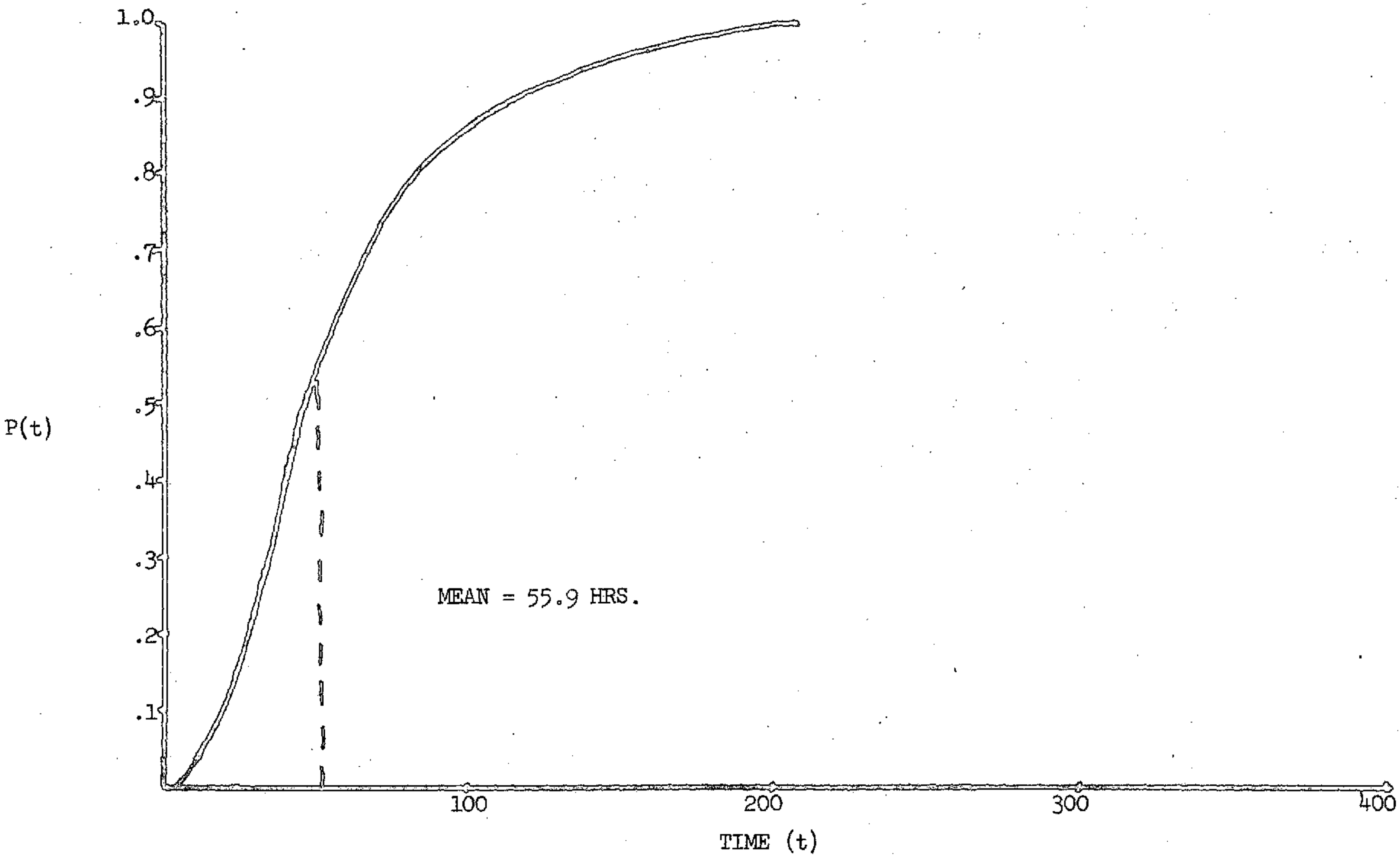

FIGURE (3)

CUMULATIVE PROBABILITY DISTRIBUTION
FOR
OVERALL S.U. SIMULATION PROCESS
(SAMPLE CASE 2)

APPENDIX B

4.0 CONCLUSIONS

In order to meet the allocated processing time of 65 hours for the SU Simulator activity, it is necessary to change the normal concept of an interface simulation process. Sample Case 1, which represents a standard simulation process, takes too long to complete when randomness is introduced into the system. Instead of completing the activity within the allocated 65 hours, it takes greater than 77 hours to complete. This is unsatisfactory. As a result, an alternate process (Sample Case 2) was proposed. This alternate did not use a simulator, but instead made use of the SU itself as a checkout device. The overall processing time for this alternative (with randomness) was 55 hours, well within the allocated 65 hours.

ENCLOSURE (1)

GPSS COMPUTER SIMULATION MODEL

SU SIMULATION PROCESS

SAMPLE CASE 1

```
** CP-67 VERSION 3 LEVEL 2  GDS MOD 23 ******************** DEV 00E ******************************************** 03/13/74 *** 08.07.17 *
```

USERID GR855

ADDRESS G GILMARTIN PLT 25 (10 YR ANNOTATED)

CREATION DATE 03/13/74 08.06.53

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I*******  C  A  L  L  D  A  T  A  *******7
I*****************************************7
                            *.*********7
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GG              DD       I****/SS
GG              DD       I***/ SSSSSSSS
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          SS       TT       AA        AA  RR     RR          TT
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 SSSSSSSSSS        TT       AA        AA  RR        RR       TT
```

08
01
A

ID GR855 03/13/74 08.06.53 G GILMARTIN PLT 25 (10 YR ANNOTATED)

FILE = TASK2   LISTING P10

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NUMBER  *LOC   OPERATION  A,B,C,D,E,F,G             COMMENTS                                CARD NUMBER
               SIMULATE
             1 FUNCTION   RN1,D2     CONSTANT
        0,1/1,0,1
             2 FUNCTION   RN1,C13     LOG NORMAL
        0,0/,025,,17/,05,,21/,1,,29/,2,,5/,4,,76/,5,,84/
        ,6,1,05/,74,1,26/,87,1,68/,89,2,1/,92,2,52/1,0,5,1
             3 FUNCTION   RN1,C24  EXPONENTIAL
        0,0/,1,,116/,2,,247/,3,,394/,4,,566/,5,,766/
        ,6,1,02/,7,1,33/,75,1,53/,8,1,78/,84,2,03/
        ,88,2,35/,9,2,55/,92,2,8/,94,3,12/
        ,95,3,32/,96,3,55/,97,3,89/,98,4,33/
        ,99,5,11/,995,5,89/,998,6,89/,999,7,78/1,0,9,9
             4 FUNCTION   RN1,C29      NORMAL
        0,0/,023,33/,067,50/,115,58/,159,67/,184,70/,212,73/
        ,242,77/,274,80/,309,83/,345,87/,382,90/,421,93/
        ,460,96/,5,100/,540,104/,579,107/,618,110/,655,113/
        ,691,117/,726,120/,758,123/,788,127/,816,130/
        ,841,133/,885,142/,933,150/,977,167/1,0,2,0
             1 TABLE      M1,0,5,1000     TIME EM/PA IN SIM ROUTINE
             2 TABLE      M1,0,5,1000     TIME FAULTY EM/PA IN SIM ROUTINE
             3 TABLE      M1,0,5,1000     TIME SU SIM IS TIED UP
             1 STORAGE    1               SU SIM
             1 VARIABLE   P2+4            TRANSACTION CONTROL
             2 FVARIABLE  P5*66/100+V3    *   NORMAL
             3 FVARIABLE  P5*33/100*FN4/100  *   DISTRIBUTION
  1            GENERATE   4368,,1,,,,F    20 MISSIONS A YEAR
  2     GGG    ASSIGN     1,0
  3            TRANSFER   ,TRAN1           TRANSP. NOT COMP
  4     TRAN2  ADVANCE    0                *   DUMMY
  5            ADVANCE    0                *      BLOCK
  6            ASSIGN     2,TRAN2
  7            MARK       4
  8            ASSIGN     5,30
  9            ADVANCE    V2               INSTALL & ASSEMBLE EM/PA
 10            QUEUE      1                WAIT FOR SU SIM
 11            ENTER      1                GET SIMULATOR
 12            DEPART     1
 13     PWRUP  ASSIGN     5,50
 14            ADVANCE    V2               POWER UP SIM.
 15            ADVANCE    410,FN3          MONITOR EM/PA INTERFACE C/O
 16            ADVANCE    100,FN3          COMPLETE EM/PA C/O
 17            SPLIT      1,DDD            SIMULTANEOUSLY SERVICE SU SIM
 18            TRANSFER   ,1,,EEE          ,1 NOT COMPATIBLE
 19            TABULATE   1                TIME EM/PA ON SIM
 20            ASSIGN     5,90
 21            ADVANCE    V2               REMOVE AND DISASSEMBLE FROM SIM
 22            ASSIGN     5,10
 23            ADVANCE    V2               TRANSPORT
 24            TERMINATE
 25     TRAN1  ASSIGN     5,20
 26            ADVANCE    V2               INCOMP. TRANS.- CONN GSE
 27            ASSIGN     5,10
 28            ADVANCE    V2               REMOVE EM/PA
```

```
31              ASSIGN     5,60
32              ADVANCE    V2            INSTALL AND ASSEMBLE EM/PA
33              QUEUE      1             WAIT FOR SU SIM
34              ENTER      1             GET SIMULATOR
35              DEPART     1
36              TRANSFER   ,PURUP
37       CKOT1  ASSIGN     3,III         *
38              TRANSFER   ,FIX1         *
39       CKOT2  ASSIGN     3,HHH         *
40              TRANSFER   ,FIX1         *    IDENTIFY WHERE
41       LLL    ASSIGN     3,JJJ         *
42              TRANSFER   ,FIX1         *    TRANSACTION CAME
43       MMM    ASSIGN     3,KKK         *
44              TRANSFER   ,FIX1         *    FROM WHEN IT
45       BBB    ASSIGN     3,AAA         *
46              TRANSFER   ,FIX1         GOES TO MAINT.
47       CCC    ASSIGN     3,GSE8        *
48              TRANSFER   ,FIX1         *
49       EEE    ASSIGN     5,30
50              ADVANCE    V2            EM/PA NOT COMP.- REMOVE EM/PA
51              ASSIGN     5,10
52              ADVANCE    V2            TRANSPORT EM/PA TO OFF LINE AREA
53              ADVANCE    80,FN3        DIAGNOSE EM/PA ANOMALIE
54              TRANSFER   .9,,FFF       .9 NO REPAIR ON SITE
55              ADVANCE    80,FN2        REPAIR ON SITE
56              TRANSFER   ,V1
57       FFF    ASSIGN     5,20
58              ADVANCE    V2            DISASSEMBLE
59              ASSIGN     5,10
60              ADVANCE    V2            TRANSPORT TO MAINT ACTIVITY
61              TABULATE   2             TIME FAULTY EM/PA IN SYSTEM
62              TERMINATE                LEAVE SYSTEM
63       DDD    ADVANCE    20,FN3        DE-SERVICE MONITOR
64              TRANSFER   .05,,LLL      FAILURE
65       JJJ    ASSIGN     5,15
66              ADVANCE    V2            DE-SERVICE COMPLETE AND CERTIFIED
67              ADVANCE    10,FN3        POST USE INSPECTION
68              TRANSFER   .05,,MMM      FAILURE
69       KKK    ADVANCE    5,FN2         OFF LINE SIM MAINT
70              SPLIT      1,GSE7        SIMULTANEOUSLY SERVICE GSE
71              ADVANCE    15,FN3        PRE USE SIMULATOR INSPECT.
72              TRANSFER   .05,III,CKOT1 FAILURE
73       III    ADVANCE    15,FN3        PRE SERVICE C/O
74              TRANSFER   .05,,CKOT2    FAILURE
75       HHH    ASSIGN     5,25
76              ADVANCE    V2            CONNECT SERVICING GSE
77              ADVANCE    30,FN3        MONITOR SERVICING
78              TRANSFER   .1,AAA,BBB    FAILURE
79       AAA    ASSIGN     5,10
80              ADVANCE    V2            COMPLETE SERVICING
81              ASSIGN     5,15
82              ADVANCE    V2            SELF TEST SIMULATOR
83              TRANSFER   .05,GSE8,CCC  FAILURE
84       FIX1   ADVANCE    110,FN3       MAINT ROUTINE DIAGNOSE PROBLEM
85              ADVANCE    255,FN2       REPAIR AND C/O
86              TRANSFER   ,P3           RETURN TO POINT OF DEPARTURE
87       GSE7   SPLIT      1,GSE1        OFFLINE GSE MAINT
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88                SPLIT      1,GSE2
89                ASSIGN     5,80
90                ADVANCE    V2                   RELOCATE FACILITIES SERVICE
91        GSE4    ASSEMBLE   3                    * GSE MAINT AND SU SIM.
92        GSE8    ASSEMBLE   2                    *  SERVICING BOTH COMPLETE
93                LEAVE      1                    SIMULATOR AVAILABLE
94                TABULATE   3                    TIME SIMULATOR IS TIED UP
95                TERMINATE
96        GSE2    TRANSFER   .17,,GSE6            ONE OF SIX USES
97                TRANSFER   ,GSE4
98        GSE6    ASSIGN     5,400
99                ADVANCE    V2                   CALIBRATE SIMULATOR INSTRU.
100               TRANSFER   ,GSE4
101       GSE1    ADVANCE    80,FN3               VALIDATE GSE
102       GSE3    TRANSFER   .25,,GSE5            ONE OF FOUR USES
103               TRANSFER   ,GSE4
104       GSE5    ADVANCE    160,FN2              MAINTAIN GSE
105               TRANSFER   ,GSE4
106               GENERATE   870000                SIMULATE FOR TEN YEARS
107               TERMINATE  1
                  START      1
                  END
```

BLOCK NUMBER	SYMBOL	REFERENCES BY CARD NUMBER					
79	AAA	70	103				
45	BBB	103					
47	CCC	108					
37	CKDT1	97					
39	CKDT2	99					
63	DDD	42					
49	EEE	43					
57	FFF	79					
84	FIX1	63	65	67	69	71	73
2	GGG						
101	GSE1	112					
96	GSE2	113					
102	GSE3						
91	GSE4	122	125	128	130		
104	GSE5	127					
98	GSE6	121					
87	GSE7	95					
92	GSE8	72	108				
75	HHH	64					
73	III	62	97				
65	JJJ	66					
69	KKK	68					
41	LLL	89					
43	MMM	93					
13	PWRUP	61					
25	TRAN1	28	54				
4	TRAN2	31					

(20)
(9)
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STORAGE	CAPACITY	AVERAGE CONTENTS	AVERAGE UTILIZATION	ENTRIES	AVERAGE TIME/TRAN	CURRENT CONTENTS	MAXIMUM CONTENTS
1	1	.248	.248	201	1074.751	1	1

QUEUE	MAXIMUM CONTENTS	AVERAGE CONTENTS	TOTAL ENTRIES	ZERO ENTRIES	PERCENT ZEROS	AVERAGE TIME/TRANS	$AVERAGE TIME/TRANS	TABLE NUMBER	CURRENT CONTENTS
1	1	.000	201	201	100.0	.000	.000		

$AVERAGE TIME/TRANS = AVERAGE TIME/TRANS EXCLUDING ZERO ENTRIES

TABLE 1

ENTRIES IN TABLE	MEAN ARGUMENT	STANDARD DEVIATION	SUM OF ARGUMENTS	
186	771.284	559.000	143459.000	NON-WEIGHTED

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TABLE 2

ENTRIES IN TABLE	MEAN ARGUMENT	STANDARD DEVIATION	SUM OF ARGUMENTS	
14	1016.928	486.000	14237.000	NON-WEIGHTED

2;

TABLE 3

ENTRIES IN TABLE	MEAN ARGUMENT	STANDARD DEVIATION	SUM OF ARGUMENTS	
200	1168.024	624.000	233605.000	NON-WEIGHTED

60
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TABLE ENTRIES TABLE	MEAN ARGUMENT	STANDARD DEVIATION	SUM OF ARGUMENTS	
186	771.284	559.000	143459.000	NON-WEIGHTED

UPPER LIMIT	OBSERVED FREQUENCY	PER CENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER	MULTIPLE OF MEAN	DEVIATION FROM MEAN
0	0	.00	.0	100.0	-.000	-1.379
5	0	.00	.0	100.0	.006	-1.370
10	0	.00	.0	100.0	.012	-1.361
15	0	.00	.0	100.0	.019	-1.352
20	0	.00	.0	100.0	.025	-1.343
25	0	.00	.0	100.0	.032	-1.335
30	0	.00	.0	100.0	.038	-1.326
35	0	.00	.0	100.0	.045	-1.317
40	0	.00	.0	100.0	.051	-1.308
45	0	.00	.0	100.0	.058	-1.299
50	0	.00	.0	100.0	.064	-1.290
55	0	.00	.0	100.0	.071	-1.281
60	0	.00	.0	100.0	.077	-1.272
65	0	.00	.0	100.0	.084	-1.263
70	0	.00	.0	100.0	.090	-1.254
75	0	.00	.0	100.0	.097	-1.245
80	0	.00	.0	100.0	.103	-1.236
85	0	.00	.0	100.0	.110	-1.227
90	0	.00	.0	100.0	.116	-1.218
95	0	.00	.0	100.0	.123	-1.209
100	0	.00	.0	100.0	.129	-1.200
105	0	.00	.0	100.0	.136	-1.191
110	0	.00	.0	100.0	.142	-1.182
115	0	.00	.0	100.0	.149	-1.174
120	0	.00	.0	100.0	.155	-1.165
125	0	.00	.0	100.0	.162	-1.156
130	0	.00	.0	100.0	.168	-1.147
135	0	.00	.0	100.0	.175	-1.138
140	1	.53	.5	99.4	.181	-1.129
145	0	.00	.5	99.4	.187	-1.120
150	0	.00	.5	99.4	.194	-1.111
155	0	.00	.5	99.4	.200	-1.102
160	0	.00	.5	99.4	.207	-1.093
165	0	.00	.5	99.4	.213	-1.084
170	1	.53	1.0	98.9	.220	-1.075
175	0	.00	1.0	98.9	.226	-1.066
180	0	.00	1.0	98.9	.233	-1.057
185	1	.53	1.6	98.3	.239	-1.048
190	1	.53	2.1	97.8	.246	-1.039
195	0	.00	2.1	97.8	.252	-1.030
200	1	.53	2.6	97.3	.259	-1.021
205	0	.00	2.6	97.3	.265	-1.013
210	1	.53	3.2	96.7	.272	-1.004
215	1	.53	3.7	96.2	.278	-.995
220	2	1.07	4.8	95.1	.285	-.986
225	0	.00	4.8	95.1	.291	-.977
230	0	.00	4.8	95.1	.298	-.968
235	1	.53	5.3	94.6	.304	-.959
240	2	1.07	6.4	93.5	.311	-.950
245	3	1.61	8.0	91.9	.317	-.941
250	1	.53	8.6	91.3	.324	-.932
255	0	.00	8.6	91.3	.330	-.923
260	1	.53	9.1	90.8	.337	-.914
265	1	.53	9.6	90.3	.343	-.905
270	1	.53	10.2	89.7	.350	-.896
275	3	1.61	11.8	88.1	.356	-.887

	1	.53	12.3	87.6	.363	-.878
285	0	.00	12.3	87.6	.369	-.869
290	0	.00	12.3	87.6	.376	-.860
295	2	1.07	13.4	86.5	.382	-.852
300	0	.00	13.4	86.5	.388	-.843
305	1	.53	13.9	86.0	.395	-.834
310	1	.53	14.5	85.4	.401	-.825
315	2	1.07	15.5	84.4	.408	-.816
320	0	.00	15.5	84.4	.414	-.807
325	3	1.61	17.2	82.7	.421	-.798
330	3	1.61	18.8	81.1	.427	-.789
335	2	1.07	19.8	80.1	.434	-.780
340	0	.00	19.8	80.1	.440	-.771
345	2	1.07	20.9	79.0	.447	-.762
350	1	.53	21.5	78.4	.453	-.753
355	0	.00	21.5	78.4	.460	-.744
360	3	1.61	23.1	76.8	.466	-.735
365	0	.00	23.1	76.8	.473	-.726
370	2	1.07	24.1	75.8	.479	-.717
375	0	.00	24.1	75.8	.486	-.708
380	1	.53	24.7	75.2	.492	-.699
385	0	.00	24.7	75.2	.499	-.691
390	0	.00	24.7	75.2	.505	-.682
395	1	.53	25.2	74.7	.512	-.673
400	1	.53	25.8	74.1	.518	-.664
405	1	.53	26.3	73.6	.525	-.655
410	0	.00	26.3	73.6	.531	-.646
415	1	.53	26.8	73.1	.538	-.637
420	1	.53	27.4	72.5	.544	-.628
425	0	.00	27.4	72.5	.551	-.619
430	0	.00	27.4	72.5	.557	-.610
435	2	1.07	28.4	71.5	.563	-.601
440	2	1.07	29.5	70.4	.570	-.592
445	0	.00	29.5	70.4	.576	-.583
450	0	.00	29.5	70.4	.583	-.574
455	1	.53	30.1	69.8	.589	-.565
460	1	.53	30.6	69.3	.596	-.556
465	2	1.07	31.7	68.2	.602	-.547
470	2	1.07	32.7	67.2	.609	-.538
475	2	1.07	33.8	66.1	.615	-.530
480	1	.53	34.4	65.5	.622	-.521
485	2	1.07	35.4	64.5	.628	-.512
490	3	1.61	37.0	62.9	.635	-.503
495	1	.53	37.6	62.3	.641	-.494
500	1	.53	38.1	61.8	.648	-.485
505	0	.00	38.1	61.8	.654	-.476
510	0	.00	38.1	61.8	.661	-.467
515	3	1.61	39.7	60.2	.667	-.458
520	3	1.61	41.3	58.6	.674	-.449
525	1	.53	41.9	58.0	.680	-.440
530	1	.53	42.4	57.5	.687	-.431
535	1	.53	43.0	56.9	.693	-.422
540	2	1.07	44.0	55.9	.700	-.413
545	0	.00	44.0	55.9	.706	-.404
550	0	.00	44.0	55.9	.713	-.395
555	1	.53	44.6	55.3	.719	-.386
560	0	.00	44.6	55.3	.726	-.377
565	1	.53	45.1	54.8	.732	-.369
570	1	.53	45.6	54.3	.739	-.360
575	1	.53	46.2	53.7	.745	-.351
580	1	.53	46.7	53.2	.751	-.342
585	0	.00	46.7	53.2	.758	-.333
590	0	.00	46.7	53.2	.764	-.324
595	2	1.07	47.8	52.1	.771	-.315
600	2	1.07	48.9	51.0	.777	-.306
605	0	.00	48.9	51.0	.784	-.297

615	1	.53	50.5	49.4	[illegible]	[illegible]
620	2	1.07	51.6	48.3	.803	-.270
625	1	.53	52.1	47.8	.810	-.261
630	1	.53	52.6	47.3	.816	-.252
635	1	.53	53.2	46.7	.823	-.243
640	2	1.07	54.3	45.6	.829	-.234
645	2	1.07	55.3	44.6	.836	-.225
650	0	.00	55.3	44.6	.842	-.216
655	1	.53	55.9	44.0	.849	-.208
660	0	.00	55.9	44.0	.855	-.199
665	0	.00	55.9	44.0	.862	-.190
670	1	.53	56.4	43.5	.868	-.181
675	2	1.07	57.5	42.4	.875	-.172
680	1	.53	58.0	41.9	.881	-.163
685	1	.53	58.6	41.3	.888	-.154
690	2	1.07	59.6	40.3	.894	-.145
695	0	.00	59.6	40.3	.901	-.136
700	3	1.61	61.2	38.7	.907	-.127
705	0	.00	61.2	38.7	.914	-.118
710	1	.53	61.8	38.1	.920	-.109
715	1	.53	62.3	37.6	.927	-.100
720	0	.00	62.3	37.6	.933	-.091
725	1	.53	62.9	37.0	.939	-.082
730	1	.53	63.4	36.5	.946	-.073
735	1	.53	63.9	36.0	.952	-.064
740	0	.00	63.9	36.0	.959	-.055
745	0	.00	63.9	36.0	.965	-.047
750	0	.00	63.9	36.0	.972	-.038
755	0	.00	63.9	36.0	.978	-.029
760	1	.53	64.5	35.4	.985	-.020
765	1	.53	65.0	34.9	.991	-.011
770	0	.00	65.0	34.9	.998	-.002
775	3	1.61	66.6	33.3	1.004	.006
780	0	.00	66.6	33.3	1.011	.015
785	0	.00	66.6	33.3	1.017	.024
790	1	.53	67.2	32.7	1.024	.033
795	0	.00	67.2	32.7	1.030	.042
800	0	.00	67.2	32.7	1.037	.051
805	0	.00	67.2	32.7	1.043	.060
810	2	1.07	68.2	31.7	1.050	.069
815	1	.53	68.8	31.1	1.056	.078
820	0	.00	68.8	31.1	1.063	.087
825	0	.00	68.8	31.1	1.069	.096
830	0	.00	68.8	31.1	1.076	.105
835	2	1.07	69.8	30.1	1.082	.113
840	1	.53	70.4	29.5	1.089	.122
845	1	.53	70.9	29.0	1.095	.131
850	1	.53	71.5	28.4	1.102	.140
855	1	.53	72.0	27.9	1.108	.149
860	0	.00	72.0	27.9	1.115	.158
865	0	.00	72.0	27.9	1.121	.167
870	0	.00	72.0	27.9	1.127	.176
875	0	.00	72.0	27.9	1.134	.185
880	1	.53	72.5	27.4	1.140	.194
885	0	.00	72.5	27.4	1.147	.203
890	0	.00	72.5	27.4	1.153	.212
895	1	.53	73.1	26.8	1.160	.221
900	0	.00	73.1	26.8	1.166	.230
905	0	.00	73.1	26.8	1.173	.239
910	0	.00	73.1	26.8	1.179	.248
915	0	.00	73.1	26.8	1.186	.257
920	0	.00	73.1	26.8	1.192	.266
925	1	.53	73.6	26.3	1.199	.274
930	1	.53	74.1	25.8	1.205	.283
935	0	.00	74.1	25.8	1.212	.292

950	2	1.07	[illegible]	25.8	1.225	.310
955	0	.00	75.2	24.7	1.231	.319
960	0	.00	75.2	24.7	1.238	.328
965	0	.00	75.2	24.7	1.244	.337
970	0	.00	75.2	24.7	1.251	.346
975	1	.53	75.8	24.1	1.257	.355
980	0	.00	75.8	24.1	1.264	.364
985	0	.00	75.8	24.1	1.270	.373
990	0	.00	75.8	24.1	1.277	.382
995	1	.53	76.3	23.6	1.283	.391
1000	0	.00	76.3	23.6	1.290	.400
1005	1	.53	76.8	23.1	1.296	.409
1010	0	.00	76.8	23.1	1.303	.418
1015	0	.00	76.8	23.1	1.309	.427
1020	2	1.07	77.9	22.0	1.315	.435
1025	0	.00	77.9	22.0	1.322	.444
1030	0	.00	77.9	22.0	1.328	.453
1035	0	.00	77.9	22.0	1.335	.462
1040	0	.00	77.9	22.0	1.341	.471
1045	0	.00	77.9	22.0	1.348	.480
1050	0	.00	77.9	22.0	1.354	.489
1055	0	.00	77.9	22.0	1.361	.498
1060	0	.00	77.9	22.0	1.367	.507
1065	0	.00	77.9	22.0	1.374	.516
1070	1	.53	78.4	21.5	1.380	.525
1075	0	.00	78.4	21.5	1.387	.534
1080	1	.53	79.0	20.9	1.393	.543
1085	0	.00	79.0	20.9	1.400	.552
1090	0	.00	79.0	20.9	1.406	.561
1095	1	.53	79.5	20.4	1.413	.570
1100	1	.53	80.1	19.8	1.419	.579
1105	0	.00	80.1	19.8	1.426	.588
1110	0	.00	80.1	19.8	1.432	.596
1115	0	.00	80.1	19.8	1.439	.605
1120	0	.00	80.1	19.8	1.445	.614
1125	0	.00	80.1	19.8	1.452	.623
1130	0	.00	80.1	19.8	1.458	.632
1135	0	.00	80.1	19.8	1.465	.641
1140	1	.53	80.6	19.3	1.471	.650
1145	0	.00	80.6	19.3	1.478	.659
1150	0	.00	80.6	19.3	1.484	.668
1155	0	.00	80.6	19.3	1.491	.677
1160	0	.00	80.6	19.3	1.497	.686
1165	1	.53	81.1	18.8	1.503	.695
1170	0	.00	81.1	18.8	1.510	.704
1175	0	.00	81.1	18.8	1.516	.713
1180	0	.00	81.1	18.8	1.523	.722
1185	0	.00	81.1	18.8	1.529	.731
1190	0	.00	81.1	18.8	1.536	.740
1195	0	.00	81.1	18.8	1.542	.749
1200	0	.00	81.1	18.8	1.549	.757
1205	0	.00	81.1	18.8	1.555	.766
1210	0	.00	81.1	18.8	1.562	.775
1215	0	.00	81.1	18.8	1.568	.784
1220	0	.00	81.1	18.8	1.575	.793
1225	0	.00	81.1	18.8	1.581	.802
1230	1	.53	81.7	18.2	1.588	.811
1235	1	.53	82.2	17.7	1.594	.820
1240	0	.00	82.2	17.7	1.601	.829
1245	0	.00	82.2	17.7	1.607	.838
1250	0	.00	82.2	17.7	1.614	.847
1255	0	.00	82.2	17.7	1.620	.856
1260	0	.00	82.2	17.7	1.627	.865
1265	0	.00	82.2	17.7	1.633	.874
					1.640	.883

1275	2	1.07	83.3	16.6	1.653	.901
1280	0	.00	83.3	16.6	1.659	.910
1285	0	.00	83.3	16.6	1.666	.918
1290	0	.00	83.3	16.6	1.672	.927
1295	0	.00	83.3	16.6	1.679	.936
1300	1	.53	83.8	16.1	1.685	.945
1305	0	.00	83.8	16.1	1.691	.954
1310	0	.00	83.8	16.1	1.698	.963
1315	0	.00	83.8	16.1	1.704	.972
1320	0	.00	83.8	16.1	1.711	.981
1325	0	.00	83.8	16.1	1.717	.990
1330	1	.53	84.4	15.5	1.724	.999
1335	0	.00	84.4	15.5	1.730	1.008
1340	1	.53	84.9	15.0	1.737	1.017
1345	0	.00	84.9	15.0	1.743	1.026
1350	0	.00	84.9	15.0	1.750	1.035
1355	0	.00	84.9	15.0	1.756	1.044
1360	0	.00	84.9	15.0	1.763	1.053
1365	1	.53	85.4	14.5	1.769	1.062
1370	0	.00	85.4	14.5	1.776	1.071
1375	0	.00	85.4	14.5	1.782	1.079
1380	0	.00	85.4	14.5	1.789	1.088
1385	1	.53	86.0	13.9	1.795	1.097
1390	0	.00	86.0	13.9	1.802	1.106
1395	0	.00	86.0	13.9	1.808	1.115
1400	0	.00	86.0	13.9	1.815	1.124
1405	0	.00	86.0	13.9	1.821	1.133
1410	1	.53	86.5	13.4	1.828	1.142
1415	0	.00	86.5	13.4	1.834	1.151
1420	0	.00	86.5	13.4	1.841	1.160
1425	0	.00	86.5	13.4	1.847	1.169
1430	0	.00	86.5	13.4	1.854	1.178
1435	0	.00	86.5	13.4	1.860	1.187
1440	0	.00	86.5	13.4	1.867	1.196
1445	0	.00	86.5	13.4	1.873	1.205
1450	1	.53	87.0	12.9	1.879	1.214
1455	0	.00	87.0	12.9	1.886	1.223
1460	1	.53	87.6	12.3	1.892	1.232
1465	0	.00	87.6	12.3	1.899	1.240
1470	0	.00	87.6	12.3	1.905	1.249
1475	0	.00	87.6	12.3	1.912	1.258
1480	2	1.07	88.7	11.2	1.918	1.267
1485	0	.00	88.7	11.2	1.925	1.276
1490	0	.00	88.7	11.2	1.931	1.285
1495	0	.00	88.7	11.2	1.938	1.294
1500	0	.00	88.7	11.2	1.944	1.303
1505	0	.00	88.7	11.2	1.951	1.312
1510	0	.00	88.7	11.2	1.957	1.321
1515	0	.00	88.7	11.2	1.964	1.330
1520	0	.00	88.7	11.2	1.970	1.339
1525	0	.00	88.7	11.2	1.977	1.348
1530	1	.53	89.2	10.7	1.983	1.357
1535	0	.00	89.2	10.7	1.990	1.366
1540	0	.00	89.2	10.7	1.996	1.375
1545	1	.53	89.7	10.2	2.003	1.384
1550	0	.00	89.7	10.2	2.009	1.393
1555	1	.53	90.3	9.6	2.016	1.401
1560	1	.53	90.8	9.1	2.022	1.410
1565	0	.00	90.8	9.1	2.029	1.419
1570	0	.00	90.8	9.1	2.035	1.428
1575	2	1.07	91.9	8.0	2.042	1.437
1580	0	.00	91.9	8.0	2.048	1.446
1585	0	.00	91.9	8.0	2.055	1.455
1590	0	.00	91.9	8.0	2.061	1.464
1595	0	.00	91.9	8.0	2.067	1.473

1610	2	1.07	93.5	6.4	2.087	1.500
1615	0	.00	93.5	6.4	2.093	1.509
1620	0	.00	93.5	6.4	2.100	1.518
1625	0	.00	93.5	6.4	2.106	1.527
1630	1	.53	94.0	5.9	2.113	1.536
1635	0	.00	94.0	5.9	2.119	1.545
1640	0	.00	94.0	5.9	2.126	1.554
1645	0	.00	94.0	5.9	2.132	1.562
1650	0	.00	94.0	5.9	2.139	1.571
1655	0	.00	94.0	5.9	2.145	1.580
1660	0	.00	94.0	5.9	2.152	1.589
1665	0	.00	94.0	5.9	2.158	1.598
1670	0	.00	94.0	5.9	2.165	1.607
1675	1	.53	94.6	5.3	2.171	1.616
1680	0	.00	94.6	5.3	2.178	1.625
1685	0	.00	94.6	5.3	2.184	1.634
1690	0	.00	94.6	5.3	2.191	1.643
1695	0	.00	94.6	5.3	2.197	1.652
1700	1	.53	95.1	4.8	2.204	1.661
1705	0	.00	95.1	4.8	2.210	1.670
1710	0	.00	95.1	4.8	2.217	1.679
1715	0	.00	95.1	4.8	2.223	1.688
1720	0	.00	95.1	4.8	2.230	1.697
1725	0	.00	95.1	4.8	2.236	1.706
1730	0	.00	95.1	4.8	2.243	1.715
1735	0	.00	95.1	4.8	2.249	1.723
1740	0	.00	95.1	4.8	2.255	1.732
1745	0	.00	95.1	4.8	2.262	1.741
1750	0	.00	95.1	4.8	2.268	1.750
1755	1	.53	95.6	4.3	2.275	1.759
1760	0	.00	95.6	4.3	2.281	1.768
1765	0	.00	95.6	4.3	2.288	1.777
1770	0	.00	95.6	4.3	2.294	1.786
1775	0	.00	95.6	4.3	2.301	1.795
1780	0	.00	95.6	4.3	2.307	1.804
1785	0	.00	95.6	4.3	2.314	1.813
1790	0	.00	95.6	4.3	2.320	1.822
1795	0	.00	95.6	4.3	2.327	1.831
1800	0	.00	95.6	4.3	2.333	1.840
1805	0	.00	95.6	4.3	2.340	1.849
1810	0	.00	95.6	4.3	2.346	1.858
1815	0	.00	95.6	4.3	2.353	1.867
1820	0	.00	95.6	4.3	2.359	1.876
1825	0	.00	95.6	4.3	2.366	1.884
1830	0	.00	95.6	4.3	2.372	1.893
1835	0	.00	95.6	4.3	2.379	1.902
1840	0	.00	95.6	4.3	2.385	1.911
1845	0	.00	95.6	4.3	2.392	1.920
1850	0	.00	95.6	4.3	2.398	1.929
1855	0	.00	95.6	4.3	2.405	1.938
1860	0	.00	95.6	4.3	2.411	1.947
1865	0	.00	95.6	4.3	2.418	1.956
1870	0	.00	95.6	4.3	2.424	1.965
1875	0	.00	95.6	4.3	2.431	1.974
1880	0	.00	95.6	4.3	2.437	1.983
1885	0	.00	95.6	4.3	2.443	1.992
1890	0	.00	95.6	4.3	2.450	2.001
1895	0	.00	95.6	4.3	2.456	2.010
1900	0	.00	95.6	4.3	2.463	2.019
1905	0	.00	95.6	4.3	2.469	2.028
1910	0	.00	95.6	4.3	2.476	2.037
1915	0	.00	95.6	4.3	2.482	2.046
1920	0	.00	95.6	4.3	2.489	2.054
1925	0	.00	95.6	4.3	2.495	2.063

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1935	0	.00	95.6	4.3	2.508	2.081
1940	0	.00	95.6	4.3	2.515	2.090
1945	0	.00	95.6	4.3	2.521	2.099
1950	0	.00	95.6	4.3	2.528	2.108
1955	0	.00	95.6	4.3	2.534	2.117
1960	0	.00	95.6	4.3	2.541	2.126
1965	0	.00	95.6	4.3	2.547	2.135
1970	0	.00	95.6	4.3	2.554	2.144
1975	0	.00	95.6	4.3	2.560	2.153
1980	1	.53	96.2	3.7	2.567	2.162
1985	0	.00	96.2	3.7	2.573	2.171
1990	0	.00	96.2	3.7	2.580	2.180
1995	0	.00	96.2	3.7	2.586	2.189
2000	0	.00	96.2	3.7	2.593	2.198
2005	0	.00	96.2	3.7	2.599	2.207
2010	0	.00	96.2	3.7	2.606	2.215
2015	0	.00	96.2	3.7	2.612	2.224
2020	0	.00	96.2	3.7	2.619	2.233
2025	0	.00	96.2	3.7	2.625	2.242
2030	0	.00	96.2	3.7	2.631	2.251
2035	0	.00	96.2	3.7	2.638	2.260
2040	0	.00	96.2	3.7	2.644	2.269
2045	1	.53	96.7	3.2	2.651	2.278
2050	0	.00	96.7	3.2	2.657	2.287
2055	0	.00	96.7	3.2	2.664	2.296
2060	0	.00	96.7	3.2	2.670	2.305
2065	0	.00	96.7	3.2	2.677	2.314
2070	0	.00	96.7	3.2	2.683	2.323
2075	0	.00	96.7	3.2	2.690	2.332
2080	0	.00	96.7	3.2	2.696	2.341
2085	0	.00	96.7	3.2	2.703	2.350
2090	0	.00	96.7	3.2	2.709	2.359
2095	0	.00	96.7	3.2	2.716	2.368
2100	0	.00	96.7	3.2	2.722	2.376
2105	0	.00	96.7	3.2	2.729	2.385
2110	0	.00	96.7	3.2	2.735	2.394
2115	1	.53	97.3	2.6	2.742	2.403
2120	0	.00	97.3	2.6	2.748	2.412
2125	0	.00	97.3	2.6	2.755	2.421
2130	0	.00	97.3	2.6	2.761	2.430
2135	0	.00	97.3	2.6	2.768	2.439
2140	0	.00	97.3	2.6	2.774	2.448
2145	0	.00	97.3	2.6	2.781	2.457
2150	0	.00	97.3	2.6	2.787	2.466
2155	0	.00	97.3	2.6	2.794	2.475
2160	0	.00	97.3	2.6	2.800	2.484
2165	0	.00	97.3	2.6	2.807	2.493
2170	0	.00	97.3	2.6	2.813	2.502
2175	0	.00	97.3	2.6	2.819	2.511
2180	0	.00	97.3	2.6	2.826	2.520
2185	0	.00	97.3	2.6	2.832	2.529
2190	0	.00	97.3	2.6	2.839	2.537
2195	0	.00	97.3	2.6	2.845	2.546
2200	0	.00	97.3	2.6	2.852	2.555
2205	0	.00	97.3	2.6	2.858	2.564
2210	0	.00	97.3	2.6	2.865	2.573
2215	0	.00	97.3	2.6	2.871	2.582
2220	0	.00	97.3	2.6	2.878	2.591
2225	0	.00	97.3	2.6	2.884	2.600
2230	0	.00	97.3	2.6	2.891	2.609
2235	0	.00	97.3	2.6	2.897	2.618
2240	0	.00	97.3	2.6	2.904	2.627
2245	0	.00	97.3	2.6	2.910	2.636
2250	0	.00	97.3	2.6	2.917	2.645
2255	0	.00	97.3	2.6	2.923	2.654

		.00	97.3	2.6	2.936	2.672
2270	0	.00	97.3	2.6	2.943	2.681
2275	0	.00	97.3	2.6	2.949	2.690
2280	0	.00	97.3	2.6	2.956	2.698
2285	0	.00	97.3	2.6	2.962	2.707
2290	0	.00	97.3	2.6	2.969	2.716
2295	0	.00	97.3	2.6	2.975	2.725
2300	0	.00	97.3	2.6	2.982	2.734
2305	0	.00	97.3	2.6	2.988	2.743
2310	0	.00	97.3	2.6	2.995	2.752
2315	0	.00	97.3	2.6	3.001	2.761
2320	1	.53	97.8	2.1	3.007	2.770
2325	0	.00	97.8	2.1	3.014	2.779
2330	0	.00	97.8	2.1	3.020	2.788
2335	0	.00	97.8	2.1	3.027	2.797
2340	0	.00	97.8	2.1	3.033	2.806
2345	0	.00	97.8	2.1	3.040	2.815
2350	0	.00	97.8	2.1	3.046	2.824
2355	0	.00	97.8	2.1	3.053	2.833
2360	0	.00	97.8	2.1	3.059	2.842
2365	0	.00	97.8	2.1	3.066	2.851
2370	0	.00	97.8	2.1	3.072	2.859
2375	0	.00	97.8	2.1	3.079	2.868
2380	0	.00	97.8	2.1	3.085	2.877
2385	0	.00	97.8	2.1	3.092	2.886
2390	0	.00	97.8	2.1	3.098	2.895
2395	0	.00	97.8	2.1	3.105	2.904
2400	0	.00	97.8	2.1	3.111	2.913
2405	0	.00	97.8	2.1	3.118	2.922
2410	1	.53	98.3	1.6	3.124	2.931
2415	0	.00	98.3	1.6	3.131	2.940
2420	0	.00	98.3	1.6	3.137	2.949
2425	0	.00	98.3	1.6	3.144	2.958
2430	0	.00	98.3	1.6	3.150	2.967
2435	0	.00	98.3	1.6	3.157	2.976
2440	0	.00	98.3	1.6	3.163	2.985
2445	0	.00	98.3	1.6	3.170	2.994
2450	0	.00	98.3	1.6	3.176	3.003
2455	0	.00	98.3	1.6	3.182	3.012
2460	0	.00	98.3	1.6	3.189	3.020
2465	0	.00	98.3	1.6	3.195	3.029
2470	0	.00	98.3	1.6	3.202	3.038
2475	0	.00	98.3	1.6	3.208	3.047
2480	0	.00	98.3	1.6	3.215	3.056
2485	0	.00	98.3	1.6	3.221	3.065
2490	0	.00	98.3	1.6	3.228	3.074
2495	0	.00	98.3	1.6	3.234	3.083
2500	0	.00	98.3	1.6	3.241	3.092
2505	0	.00	98.3	1.6	3.247	3.101
2510	0	.00	98.3	1.6	3.254	3.110
2515	0	.00	98.3	1.6	3.260	3.119
2520	0	.00	98.3	1.6	3.267	3.128
2525	0	.00	98.3	1.6	3.273	3.137
2530	0	.00	98.3	1.6	3.280	3.146
2535	0	.00	98.3	1.6	3.286	3.155
2540	0	.00	98.3	1.6	3.293	3.164
2545	0	.00	98.3	1.6	3.299	3.173
2550	0	.00	98.3	1.6	3.306	3.181
2555	0	.00	98.3	1.6	3.312	3.190
2560	0	.00	98.3	1.6	3.319	3.199
2565	0	.00	98.3	1.6	3.325	3.208
2570	0	.00	98.3	1.6	3.332	3.217
2575	0	.00	98.3	1.6	3.338	3.226
2580	0	.00	98.3	1.6	3.345	3.235
2585	0	.00	98.3	1.6	3.351	3.244

2595	0	.00	98.3	1.6	3.358	3.253
2600	0	.00	98.3	1.6	3.364	3.262
2605	0	.00	98.3	1.6	3.370	3.271
2610	0	.00	98.3	1.6	3.377	3.280
2615	0	.00	98.3	1.6	3.383	3.289
2620	0	.00	98.3	1.6	3.390	3.298
2625	0	.00	98.3	1.6	3.396	3.307
2630	0	.00	98.3	1.6	3.403	3.316
2635	0	.00	98.3	1.6	3.409	3.325
2640	0	.00	98.3	1.6	3.416	3.334
2645	0	.00	98.3	1.6	3.422	3.342
2650	0	.00	98.3	1.6	3.429	3.351
2655	0	.00	98.3	1.6	3.435	3.360
2660	0	.00	98.3	1.6	3.442	3.369
2665	0	.00	98.3	1.6	3.448	3.378
2670	0	.00	98.3	1.6	3.455	3.387
2675	0	.00	98.3	1.6	3.461	3.396
2680	0	.00	98.3	1.6	3.468	3.405
2685	0	.00	98.3	1.6	3.474	3.414
2690	0	.00	98.3	1.6	3.481	3.423
2695	0	.00	98.3	1.6	3.487	3.432
2700	0	.00	98.3	1.6	3.494	3.441
2705	0	.00	98.3	1.6	3.500	3.450
2710	0	.00	98.3	1.6	3.507	3.459
2715	0	.00	98.3	1.6	3.513	3.468
2720	0	.00	98.3	1.6	3.520	3.477
2725	0	.00	98.3	1.6	3.526	3.486
2730	0	.00	98.3	1.6	3.533	3.495
2735	0	.00	98.3	1.6	3.539	3.503
2740	0	.00	98.3	1.6	3.546	3.512
2745	0	.00	98.3	1.6	3.552	3.521
2750	0	.00	98.3	1.6	3.558	3.530
2755	0	.00	98.3	1.6	3.565	3.539
2760	0	.00	98.3	1.6	3.571	3.548
2765	0	.00	98.3	1.6	3.578	3.557
2770	0	.00	98.3	1.6	3.584	3.566
2775	0	.00	98.3	1.6	3.591	3.575
2780	0	.00	98.3	1.6	3.597	3.584
2785	0	.00	98.3	1.6	3.604	3.593
2790	0	.00	98.3	1.6	3.610	3.602
2795	0	.00	98.3	1.6	3.617	3.611
2800	0	.00	98.3	1.6	3.623	3.620
2805	0	.00	98.3	1.6	3.630	3.629
2810	0	.00	98.3	1.6	3.636	3.638
2815	1	.53	98.9	1.0	3.643	3.647
2820	0	.00	98.9	1.0	3.649	3.656
2825	0	.00	98.9	1.0	3.656	3.664
2830	0	.00	98.9	1.0	3.662	3.673
2835	0	.00	98.9	1.0	3.669	3.682
2840	0	.00	98.9	1.0	3.675	3.691
2845	0	.00	98.9	1.0	3.682	3.700
2850	0	.00	98.9	1.0	3.688	3.709
2855	0	.00	98.9	1.0	3.695	3.718
2860	0	.00	98.9	1.0	3.701	3.727
2865	0	.00	98.9	1.0	3.708	3.736
2870	0	.00	98.9	1.0	3.714	3.745
2875	0	.00	98.9	1.0	3.721	3.754
2880	0	.00	98.9	1.0	3.727	3.763
2885	0	.00	98.9	1.0	3.734	3.772
2890	0	.00	98.9	1.0	3.740	3.781
2895	0	.00	98.9	1.0	3.746	3.790
2900	0	.00	98.9	1.0	3.753	3.799
2905	0	.00	98.9	1.0	3.759	3.808
2910	0	.00	98.9	1.0	3.766	3.817
2915	0	.00	98.9	1.0	3.772	3.825
	0	.00	[illegible]	1.0	3.779	[illegible]

2920	1	.53	99.4	.5	3.785	3.843
2925	0	.00	99.4	.5	3.792	3.852
2930	0	.00	99.4	.5	3.798	3.861
2935	0	.00	99.4	.5	3.805	3.870
2940	0	.00	99.4	.5	3.811	3.879
2945	0	.00	99.4	.5	3.818	3.888
2950	0	.00	99.4	.5	3.824	3.897
2955	0	.00	99.4	.5	3.831	3.906
2960	0	.00	99.4	.5	3.837	3.915
2965	0	.00	99.4	.5	3.844	3.924
2970	0	.00	99.4	.5	3.850	3.933
2975	0	.00	99.4	.5	3.857	3.942
2980	0	.00	99.4	.5	3.863	3.951
2985	0	.00	99.4	.5	3.870	3.960
2990	0	.00	99.4	.5	3.876	3.969
2995	0	.00	99.4	.5	3.883	3.978
3000	0	.00	99.4	.5	3.889	3.986
3005	0	.00	99.4	.5	3.896	3.995
3010	0	.00	99.4	.5	3.902	4.004
3015	0	.00	99.4	.5	3.909	4.013
3020	0	.00	99.4	.5	3.915	4.022
3025	0	.00	99.4	.5	3.922	4.031
3030	0	.00	99.4	.5	3.928	4.040
3035	0	.00	99.4	.5	3.934	4.049
3040	0	.00	99.4	.5	3.941	4.058
3045	0	.00	99.4	.5	3.947	4.067
3050	0	.00	99.4	.5	3.954	4.076
3055	0	.00	99.4	.5	3.960	4.085
3060	0	.00	99.4	.5	3.967	4.094
3065	0	.00	99.4	.5	3.973	4.103
3070	0	.00	99.4	.5	3.980	4.112
3075	0	.00	99.4	.5	3.986	4.121
3080	0	.00	99.4	.5	3.993	4.130
3085	0	.00	99.4	.5	3.999	4.139
3090	0	.00	99.4	.5	4.006	4.147
3095	0	.00	99.4	.5	4.012	4.156
3100	0	.00	99.4	.5	4.019	4.165
3105	0	.00	99.4	.5	4.025	4.174
3110	0	.00	99.4	.5	4.032	4.183
3115	0	.00	99.4	.5	4.038	4.192
3120	0	.00	99.4	.5	4.045	4.201
3125	0	.00	99.4	.5	4.051	4.210
3130	0	.00	99.4	.5	4.058	4.219
3135	0	.00	99.4	.5	4.064	4.228
3140	0	.00	99.4	.5	4.071	4.237
3145	0	.00	99.4	.5	4.077	4.246
3150	0	.00	99.4	.5	4.084	4.255
3155	0	.00	99.4	.5	4.090	4.264
3160	0	.00	99.4	.5	4.097	4.273
3165	0	.00	99.4	.5	4.103	4.292
3170	0	.00	99.4	.5	4.110	4.291
3175	0	.00	99.4	.5	4.116	4.300
3180	0	.00	99.4	.5	4.122	4.308
3185	0	.00	99.4	.5	4.129	4.317
3190	0	.00	99.4	.5	4.135	4.326
3195	0	.00	99.4	.5	4.142	4.335
3200	0	.00	99.4	.5	4.148	4.344
3205	0	.00	99.4	.5	4.155	4.353
3210	0	.00	99.4	.5	4.161	4.362
3215	0	.00	99.4	.5	4.168	4.371
3220	0	.00	99.4	.5	4.174	4.380
3225	0	.00	99.4	.5	4.181	4.389
3230	0	.00	99.4	.5	4.187	4.398
3235	0	.00	99.4	.5	4.194	4.407
3240	0	.00	99.4	.5	4.200	4.416
3245	0	.00	99.4	.5	[illegible]	[illegible]

3250	0	.00	99.4	.5	4.213	4.434
3255	0	.00	99.4	.5	4.220	4.443
3260	0	.00	99.4	.5	4.226	4.452
3265	0	.00	99.4	.5	4.233	4.461
3270	0	.00	99.4	.5	4.239	4.469
3275	0	.00	99.4	.5	4.246	4.478
3280	0	.00	99.4	.5	4.252	4.487
3285	0	.00	99.4	.5	4.259	4.496
3290	0	.00	99.4	.5	4.265	4.505
3295	0	.00	99.4	.5	4.272	4.514
3300	0	.00	99.4	.5	4.278	4.523
3305	0	.00	99.4	.5	4.285	4.532
3310	0	.00	99.4	.5	4.291	4.541
3315	0	.00	99.4	.5	4.298	4.550
3320	0	.00	99.4	.5	4.304	4.559
3325	0	.00	99.4	.5	4.310	4.568
3330	0	.00	99.4	.5	4.317	4.577
3335	0	.00	99.4	.5	4.323	4.586
3340	0	.00	99.4	.5	4.330	4.595
3345	0	.00	99.4	.5	4.336	4.604
3350	0	.00	99.4	.5	4.343	4.613
3355	0	.00	99.4	.5	4.349	4.622
3360	0	.00	99.4	.5	4.356	4.630
3365	0	.00	99.4	.5	4.362	4.639
3370	0	.00	99.4	.5	4.369	4.648
3375	0	.00	99.4	.5	4.375	4.657
3380	0	.00	99.4	.5	4.382	4.666
3385	0	.00	99.4	.5	4.388	4.675
3390	0	.00	99.4	.5	4.395	4.684
3395	0	.00	99.4	.5	4.401	4.693
3400	0	.00	99.4	.5	4.408	4.702
3405	0	.00	99.4	.5	4.414	4.711
3410	0	.00	99.4	.5	4.421	4.720
3415	0	.00	99.4	.5	4.427	4.729
3420	0	.00	99.4	.5	4.434	4.738
3425	0	.00	99.4	.5	4.440	4.747
3430	0	.00	99.4	.5	4.447	4.756
3435	0	.00	99.4	.5	4.453	4.765
3440	0	.00	99.4	.5	4.460	4.774
3445	0	.00	99.4	.5	4.466	4.783
3450	0	.00	99.4	.5	4.473	4.791
3455	0	.00	99.4	.5	4.479	4.800
3460	0	.00	99.4	.5	4.486	4.809
3465	0	.00	99.4	.5	4.492	4.818
3470	0	.00	99.4	.5	4.498	4.827
3475	0	.00	99.4	.5	4.505	4.836
3480	0	.00	99.4	.5	4.511	4.845
3485	0	.00	99.4	.5	4.518	4.854
3490	0	.00	99.4	.5	4.524	4.863
3495	0	.00	99.4	.5	4.531	4.872
3500	0	.00	99.4	.5	4.537	4.881
3505	0	.00	99.4	.5	4.544	4.890
3510	0	.00	99.4	.5	4.550	4.899
3515	0	.00	99.4	.5	4.557	4.908
3520	0	.00	99.4	.5	4.563	4.917
3525	0	.00	99.4	.5	4.570	4.926
3530	0	.00	99.4	.5	4.576	4.935
3535	0	.00	99.4	.5	4.583	4.944
3540	0	.00	99.4	.5	4.589	4.952
3545	0	.00	99.4	.5	4.596	4.961
3550	0	.00	99.4	.5	4.602	4.970
3555	0	.00	99.4	.5	4.609	4.979
3560	0	.00	99.4	.5	4.615	4.988
3565	0	.00	99.4	.5	4.622	4.997
3570	0	.00	99.4	.5	4.628	5.006
3575	0	[illegible]	[illegible]			

31

3580	0	.00	99.4	.5	4.641	5.024
3585	0	.00	99.4	.5	4.648	5.033
3590	0	.00	99.4	.5	4.654	5.042
3595	0	.00	99.4	.5	4.661	5.051
3600	0	.00	99.4	.5	4.667	5.060
3605	0	.00	99.4	.5	4.674	5.069
3610	0	.00	99.4	.5	4.680	5.078
3615	0	.00	99.4	.5	4.686	5.087
3620	0	.00	99.4	.5	4.693	5.096
3625	0	.00	99.4	.5	4.699	5.105
3630	0	.00	99.4	.5	4.706	5.113
3635	0	.00	99.4	.5	4.712	5.122
3640	0	.00	99.4	.5	4.719	5.131
3645	0	.00	99.4	.5	4.725	5.140
3650	0	.00	99.4	.5	4.732	5.149
3655	0	.00	99.4	.5	4.738	5.158
3660	0	.00	99.4	.5	4.745	5.167
3665	0	.00	99.4	.5	4.751	5.176
3670	0	.00	99.4	.5	4.758	5.185
3675	0	.00	99.4	.5	4.764	5.194
3680	0	.00	99.4	.5	4.771	5.203
3685	0	.00	99.4	.5	4.777	5.212
3690	0	.00	99.4	.5	4.784	5.221
3695	0	.00	99.4	.5	4.790	5.230
3700	0	.00	99.4	.5	4.797	5.239
3705	0	.00	99.4	.5	4.803	5.248
3710	0	.00	99.4	.5	4.810	5.257
3715	0	.00	99.4	.5	4.816	5.266
3720	0	.00	99.4	.5	4.823	5.274
3725	0	.00	99.4	.5	4.829	5.283
3730	0	.00	99.4	.5	4.836	5.292
3735	0	.00	99.4	.5	4.842	5.301
3740	0	.00	99.4	.5	4.849	5.310
3745	0	.00	99.4	.5	4.855	5.319
3750	0	.00	99.4	.5	4.862	5.328
3755	0	.00	99.4	.5	4.868	5.337
3760	0	.00	99.4	.5	4.874	5.346
3765	1	.53	100.0	.0	4.881	5.355

REMAINING FREQUENCIES ARE ALL ZERO

```
** CP-67 VERSION 3 LEVEL 2  GDS MOD 23 ****************** DEV 009 ****************************************** 03/13/74 *** 08.23.36 **
```

```
USERID              GR855
ADDRESS             G GILMARTIN PLT 25 (10 YR CONST ANNO)
CREATION DATE       03/13/74          08.23.13
```

```
I****************************************7
I*******  C  A  L  L  D  A  T  A  *******7
I**************************************7
                           '.********7
 GGGGGGGGG    DDDDDDDD   /******/SSSSSS
GGGGGGGGGGG  DDDDDDDDD/******/SSSSSSSS
GG        GG  DD       /******/        SS
GG            DD      I*****/
GG            DD      I****/SS
GG            DD      I***/ SSSSSSSSS
GG      GGGGG DD      I**/   SSSSSSSSS
GG      GGGGG DD      I*/           SSS
GG         GG DD      I/D            SS
GG         GG DD      .D   SS        SS
GGGGGGGGGGG  DDDDDDDDD     SSSSSSSSSSS
 GGGGGGGGG   DDDDDDDD       SSSSSSSSS
```

```
 GGGGGGGGG   RRRRRRRRRRR    8888888888   55555555555  55555555555
GGGGGGGGGGG  RRRRRRRRRRRR  88888888888   55555555555  55555555555
GG        GG RR        RR  88        88  55           55
GG           RR        RR  88        88  55           55
GG           RR        RR   88      88   55           55
GG           RRRRRRRRRRR     88888888    555555555    555555555
GG     GGGGG RRRRRRRRRR      88888888    5555555555   5555555555
GG     GGGGG RR     RR      88      88           55            55
GG        GG RR      RR    88        88           55            55
GG        GG RR       RR   88        88           55            55
GGGGGGGGGGG  RR        RR  88888888888   55555555555  55555555555
 GGGGGGGGG   RR        RR   8888888888   5555555555   5555555555
```

```
 SSSSSSSSSS  TTTTTTTTTTTT   AAAAAAAAAA   RRRRRRRRRRR   TTTTTTTTTTTT
SSSSSSSSSSSS TTTTTTTTTTTT  AAAAAAAAAAAA  RRRRRRRRRRRR  TTTTTTTTTTTT
SS        SS      TT       AA        AA  RR        RR       TT
SS                TT       AA        AA  RR        RR       TT
SSS               TT       AA        AA  RR        RR       TT
 SSSSSSSSS        TT       AAAAAAAAAAAA  RRRRRRRRRRRR       TT
  SSSSSSSSS       TT       AAAAAAAAAAAA  RRRRRRRRRRR        TT
         SSS      TT       AA        AA  RR    RR           TT
          SS      TT       AA        AA  RR     RR          TT
SS        SS      TT       AA        AA  RR      RR         TT
SSSSSSSSSSSS      TT       AA        AA  RR       RR        TT
 SSSSSSSSSS       TT       AA        AA  RR        RR       TT
```

```
ID      GR855    03/13/74  08.23.13   G GILMARTIN PLT 25 (10 YR CONST ANNO)
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```
BLOCK
NUMBER *LOC   OPERATION  A,B,C,D,E,F,G                 COMMENTS                                  CARD
                                                                                                 NUMBER
              SIMULATE                                                                            1
            1 FUNCTION   RN1,D2     CONSTANT                                                      2
       0,1/1.0,1                                                                                  3
            2 FUNCTION   RN1,D2     CONSTANT                                                      4
       0,1/1.0,1                                                                                  5
            3 FUNCTION   RN1,D2  CONSTANT                                                         6
       0,1/1.0,1                                                                                  7
            4 FUNCTION   RN1,C29       NORMAL                                                     8
       0,0/.023,33/.067,50/.115,58/.159,67/.184,70/.212,73/                                       9
       .242,77/.274,80/.309,83/.345,87/.382,90/.421,93/                                          10
       .460,96/.5,100/.540,104/.579,107/.618,110/.655,113/                                       11
       .691,117/.726,120/.758,123/.788,127/.816,130/                                             12
       .841,133/.885,142/.933,150/.977,167/1.0,2.0                                               13
            1 TABLE      M1,0,5,1000       TIME EM/PA IN SIM ROUTINE                             14
            2 TABLE      M1,0,5,1000       TIME FAULTY EM/PA IN SIM ROUTINE                      15
            3 TABLE      M1,0,5,1000       TIME SU SIM IS TIED UP                                16
            1 STORAGE    1                 SU SIM                                                17
            1 VARIABLE   P2+4              TRANSACTION CONTROL                                   18
            2 FVARIABLE  P5       *   CONSTANT                                                   19
            3 FVARIABLE  P5*33/100*FN4/100  *    DISTRIBUTION                                    20
   1          GENERATE   4368,,1,,,,F      20 MISSIONS A YEAR                                    21
   2   GGG    ASSIGN     1,0                                                                     22
   3          TRANSFER   ,TRAN1              TRANSP. NOT COMP                                    23
   4   TRAN2  ADVANCE    0                   *   DUMMY                                           24
   5          ADVANCE    0                   *     BLOCK                                         25
   6          ASSIGN     2,TRAN2                                                                 26
   7          MARK       4                                                                       27
   8          ASSIGN     5,30                                                                    28
   9          ADVANCE    V2                  INSTALL & ASSEMBLE EM/PA                            29
  10          QUEUE      1                   WAIT FOR SU SIM                                     30
  11          ENTER      1                   GET SIMULATOR                                       31
  12          DEPART     1                                                                       32
  13   PWRUP  ASSIGN     5,50                                                                    33
  14          ADVANCE    V2                  POWER UP SIM.                                       34
  15          ADVANCE    410,FN3             MONITOR EM/PA INTERFACE C/O                         35
  16          ADVANCE    100,FN3             COMPLETE EM/PA C/O                                  36
  17          SPLIT      1,DDD               SIMULTANEOUSLY SERVICE SU SIM                       37
  18          TRANSFER   .1,,EEE             .1 NOT COMPATIBLE                                   38
  19          TABULATE   1                   TIME EM/PA ON SIM                                   39
  20          ASSIGN     5,30                                                                    40
  21          ADVANCE    V2                  REMOVE AND DISASSEMBLE FROM SIM                     41
  22          ASSIGN     5,10                                                                    42
  23          ADVANCE    V2                  TRANSPORT                                           43
  24          TERMINATE                                                                          44
  25   TRAN1  ASSIGN     5,20                                                                    45
  26          ADVANCE    V2                  INCOMP. TRANS.- CONN GSE                            46
  27          ASSIGN     5,10                                                                    47
  28          ADVANCE    V2                  REMOVE EM/PA                                        48
  29          ASSIGN     2,TRAN1                                                                 49
  30          MARK       4                                                                       50
  31          ASSIGN     5,60                                                                    51
  32          ADVANCE    V2                  INSTALL AND ASSEMBLE EM/PA                          52
  33          QUEUE      1                   WAIT FOR SU SIM                                     53
  34          ENTER      1                   GET SIMULATOR                                       54
  35          DEPART     1                                                                       55
```

```
        TRANSFER   ,PWRUP
CKOT1   ASSIGN     3,III                *
        TRANSFER   ,FIX1                *
CKOT2   ASSIGN     3,HHH                *
        TRANSFER   ,FIX1                *   IDENTIFY WHERE
LLL     ASSIGN     3,JJJ                *
        TRANSFER   ,FIX1                *   TRANSACTION CAME
MMM     ASSIGN     3,KKK                *
        TRANSFER   ,FIX1                *   FROM WHEN IT
BBB     ASSIGN     3,AAA                *
        TRANSFER   ,FIX1                GOES TO MAINT.
CCC     ASSIGN     3,GSE8               *
        TRANSFER   ,FIX1                *
FEE     ASSIGN     5,30
        ADVANCE    V2                   EM/PA NOT COMP.- REMOVE EM/PA
        ASSIGN     5,10
        ADVANCE    V2                   TRANSPORT EM/PA TO OFF LINE AREA
        ADVANCE    80,FN3               DIAGNOSE EM/PA ANOMALIE
        TRANSFER   .9,,FFF              .9 NO REPAIR ON SITE
        ADVANCE    80,FN2               REPAIR ON SITE
        TRANSFER   ,V1
FFF     ASSIGN     5,20
        ADVANCE    V2                   DISASSEMBLE
        ASSIGN     5,10
        ADVANCE    V2                   TRANSPORT TO MAINT ACTIVITY
        TABULATE   2                    TIME FAULTY EM/PA IN SYSTEM
        TERMINATE                        LEAVE SYSTEM
DDD     ADVANCE    20,FN3               DE-SERVICE MONITOR
        TRANSFER   .05,,LLL             FAILURE ?
JJJ     ASSIGN     5,15
        ADVANCE    V2                   DE-SERVICE COMPLETE AND CERTIFIED
        ADVANCE    10,FN3               POST USE INSPECTION
        TRANSFER   .05,,MMM             FAILURE ?
KKK     ADVANCE    5,FN2                OFF LINE SIM MAINT
        SPLIT      1,GSE7               SIMULTANEOUSLY SERVICE GSE
        ADVANCE    15,FN3               PRE USE SIMULATOR INSPECT.
        TRANSFER   .05,III,CKOT1        FAILURE ?
III     ADVANCE    15,FN3               PRE SERVICE C/O
        TRANSFER   .05,,CKOT2           FAILURE ?
HHH     ASSIGN     5,25
        ADVANCE    V2                   CONNECT SERVICING GSE
        ADVANCE    30,FN3               MONITOR SERVICING
        TRANSFER   .1,AAA,BBB           FAILURE ?
AAA     ASSIGN     5,10
        ADVANCE    V2                   COMPLETE SERVICING
        ASSIGN     5,15
        ADVANCE    V2                   SELF TEST SIMULATOR
        TRANSFER   .05,GSE8,CCC         FAILURE ?
FIX1    ADVANCE    110,FN3              MAINT ROUTINE DIAGNOSE PROBLEM
        ADVANCE    255,FN2              REPAIR AND C/O
        TRANSFER   ,P3                  RETURN TO POINT OF DEPARTURE
GSE7    SPLIT      1,GSE1               OFFLINE GSE MAINT
        SPLIT      1,GSE2
        ASSIGN     5,30
        ADVANCE    V2                   RELOCATE FACILITIES SERVICE
GSE4    ASSEMBLE   3                    *  GSE MAINT AND SU SIM.
GSE8    ASSEMBLE   2                    *    SERVICING BOTH COMPLETE
```

```
93          LEAVE       1               SIMULATOR AVAILABLE
94          TABULATE    3               TIME SIMULATOR IS TIED UP
95          TERMINATE
96    GSE2  TRANSFER    .17,,GSE6       ONE OF SIX USES
97          TRANSFER    ,GSE4
98    GSE6  ASSIGN      5,400
99          ADVANCE     V2              CALIBRATE SIMULATOR INSTRU.
100         TRANSFER    ,GSE4
101   GSE1  ADVANCE     80,FN3          VALIDATE GSE
102   GSE3  TRANSFER    .25,,GSE5       ONE OF FOUR USES
103         TRANSFER    ,GSE4
104   GSE5  ADVANCE     160,FN2         MAINTAIN GSE
105         TRANSFER    ,GSE4
106         GENERATE    870000           SIMULATE FOR TEN YEARS
107         TERMINATE   1
            START       1
            END
```

BLOCK NUMBER	SYMBOL	REFERENCES BY CARD NUMBER					
79	AAA	65	98				
45	BBB	98					
47	CCC	103					
37	CKOT1	92					
39	CKOT2	94					
63	DDD	37					
49	EEE	38					
57	FFF	74					
94	FIX1	58	60	62	64	66	68
2	GGG						
101	GSE1	107					
96	GSE2	108					
102	GSE3						
91	GSE4	117	120	123	125		
104	GSE5	122					
93	GSE6	116					
87	GSE7	90					
92	GSE8	67	103				
75	HHH	59					
73	III	57	92				
65	JJJ	61					
69	KKK	63					
41	LLL	84					
43	MMM	88					
13	PWRU2	56					
25	TRAN1	23	49				
4	TRAN2	26					

RELATIVE CLOCK 870000 ABSOLUTE CLOCK 870000
BLOCK COUNTS

BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL
1	0	200	11	0	0	21	0	177	31	0	202	41	0	12
2	0	200	12	0	0	22	0	177	32	0	202	42	0	12
3	0	200	13	0	202	23	0	177	33	0	202	43	0	12
4	0	0	14	0	202	24	0	177	34	0	202	44	0	12
5	0	0	15	0	202	25	0	200	35	0	202	45	0	13
6	0	0	16	0	202	26	0	200	36	0	202	46	0	13
7	0	0	17	0	404	27	0	200	37	0	9	47	0	9
8	0	0	18	0	202	28	0	200	38	0	9	48	0	9
9	0	0	19	0	177	29	0	202	39	0	17	49	0	25
10	0	0	20	0	177	30	0	202	40	0	17	50	0	25

BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL
51	0	25	61	0	22	71	0	202	81	0	201	91	1	202
52	0	25	62	0	22	72	0	202	82	0	201	92	0	201
53	1	25	63	0	202	73	0	202	83	0	201	93	0	201
54	0	24	64	0	202	74	0	202	84	0	72	94	0	201
55	0	2	65	0	202	75	0	202	85	0	72	95	0	201
56	0	2	66	0	202	76	0	202	86	0	72	96	0	202
57	0	22	67	0	202	77	1	202	87	0	404	97	0	170
58	0	22	68	0	202	78	0	201	88	0	404	98	0	32
59	0	22	69	0	202	79	0	201	89	0	202	99	0	32
60	0	22	70	0	404	80	0	201	90	1	202	100	0	32

BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL
101	1	202												
102	0	201												
103	0	144												
104	0	57												
105	0	57												
106	0	1												
107	0	1												

STORAGE	CAPACITY	AVERAGE CONTENTS	AVERAGE UTILIZATION	ENTRIES	AVERAGE TIME/TRAN	CURRENT CONTENTS	MAXIMUM CONTENTS
1	1	.211	.211	202	909.588	1	1

QUEUE	MAXIMUM CONTENTS	AVERAGE CONTENTS	TOTAL ENTRIES	ZERO ENTRIES	PERCENT ZEROS	AVERAGE TIME/TRANS	$AVERAGE TIME/TRANS	TABLE NUMBER	CURRENT CONTENTS
1	1	.000	202	202	100.0	.000	.000		

$AVERAGE TIME/TRANS = AVERAGE TIME/TRANS EXCLUDING ZERO ENTRIES

TABLE 1

ENTRIES IN TABLE	MEAN ARGUMENT	STANDARD DEVIATION	SUM OF ARGUMENTS	
177	654.632	61.562	115870.000	NON-WEIGHTED

TABLE 2

ENTRIES IN TABLE	MEAN ARGUMENT	STANDARD DEVIATION	SUM OF ARGUMENTS	
22	837.272	174.812	18420.000	NON-WEIGHTED

TABLE 3

ENTRIES IN TABLE	MEAN ARGUMENT	STANDARD DEVIATION	SUM OF ARGUMENTS	
201	1008.905	239.125	202790.000	NON-WEIGHTED

1538A

TABLE 1

ENTRIES IN TABLE	MEAN ARGUMENT	STANDARD DEVIATION	SUM OF ARGUMENTS	
177	654.632	61.562	115870.000	NON-WEIGHTED

UPPER LIMIT	OBSERVED FREQUENCY	PER CENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER	MULTIPLE OF MEAN	DEVIATION FROM MEAN
0	0	.00	.0	100.0	-.000	-10.633
5	0	.00	.0	100.0	.007	-10.552
10	0	.00	.0	100.0	.015	-10.471
15	0	.00	.0	100.0	.022	-10.389
20	0	.00	.0	100.0	.030	-10.308
25	0	.00	.0	100.0	.038	-10.227
30	0	.00	.0	100.0	.045	-10.146
35	0	.00	.0	100.0	.053	-10.065
40	0	.00	.0	100.0	.061	-9.983
45	0	.00	.0	100.0	.068	-9.902
50	0	.00	.0	100.0	.076	-9.821
55	0	.00	.0	100.0	.084	-9.740
60	0	.00	.0	100.0	.091	-9.659
65	0	.00	.0	100.0	.099	-9.577
70	0	.00	.0	100.0	.106	-9.496
75	0	.00	.0	100.0	.114	-9.415
80	0	.00	.0	100.0	.122	-9.334
85	0	.00	.0	100.0	.129	-9.252
90	0	.00	.0	100.0	.137	-9.171
95	0	.00	.0	100.0	.145	-9.090
100	0	.00	.0	100.0	.152	-9.009
105	0	.00	.0	100.0	.160	-8.928
110	0	.00	.0	100.0	.168	-8.846
115	0	.00	.0	100.0	.175	-8.765
120	0	.00	.0	100.0	.183	-8.684
125	0	.00	.0	100.0	.190	-8.603
130	0	.00	.0	100.0	.198	-8.521
135	0	.00	.0	100.0	.206	-8.440
140	0	.00	.0	100.0	.213	-8.359
145	0	.00	.0	100.0	.221	-8.278
150	0	.00	.0	100.0	.229	-8.197
155	0	.00	.0	100.0	.236	-8.115
160	0	.00	.0	100.0	.244	-8.034
165	0	.00	.0	100.0	.252	-7.953
170	0	.00	.0	100.0	.259	-7.872
175	0	.00	.0	100.0	.267	-7.790
180	0	.00	.0	100.0	.274	-7.709
185	0	.00	.0	100.0	.282	-7.628
190	0	.00	.0	100.0	.290	-7.547
195	0	.00	.0	100.0	.297	-7.466
200	0	.00	.0	100.0	.305	-7.384
205	0	.00	.0	100.0	.313	-7.303
210	0	.00	.0	100.0	.320	-7.222
215	0	.00	.0	100.0	.328	-7.141
220	0	.00	.0	100.0	.336	-7.060
225	0	.00	.0	100.0	.343	-6.978
230	0	.00	.0	100.0	.351	-6.897
235	0	.00	.0	100.0	.358	-6.816
240	0	.00	.0	100.0	.366	-6.735
245	0	.00	.0	100.0	.374	-6.653
250	0	.00	.0	100.0	.381	-6.572
255	0	.00	.0	100.0	.389	-6.491
260	0	.00	.0	100.0	.397	-6.410
265	0	.00	.0	100.0	.404	-6.329
270	0	.00	.0	100.0	[illegible]	[illegible]

285	0	.00	.0	100.0	.435	-6.004
290	0	.00	.0	100.0	.442	-5.922
295	0	.00	.0	100.0	.450	-5.841
300	0	.00	.0	100.0	.458	-5.760
305	0	.00	.0	100.0	.465	-5.679
310	0	.00	.0	100.0	.473	-5.598
315	0	.00	.0	100.0	.481	-5.516
320	0	.00	.0	100.0	.488	-5.435
325	0	.00	.0	100.0	.496	-5.354
330	0	.00	.0	100.0	.504	-5.273
335	0	.00	.0	100.0	.511	-5.192
340	0	.00	.0	100.0	.519	-5.110
345	0	.00	.0	100.0	.527	-5.029
350	0	.00	.0	100.0	.534	-4.948
355	0	.00	.0	100.0	.542	-4.867
360	0	.00	.0	100.0	.549	-4.785
365	0	.00	.0	100.0	.557	-4.704
370	0	.00	.0	100.0	.565	-4.623
375	0	.00	.0	100.0	.572	-4.542
380	0	.00	.0	100.0	.580	-4.461
385	0	.00	.0	100.0	.588	-4.379
390	0	.00	.0	100.0	.595	-4.298
395	0	.00	.0	100.0	.603	-4.217
400	0	.00	.0	100.0	.611	-4.136
405	0	.00	.0	100.0	.618	-4.054
410	0	.00	.0	100.0	.626	-3.973
415	0	.00	.0	100.0	.633	-3.892
420	0	.00	.0	100.0	.641	-3.811
425	0	.00	.0	100.0	.649	-3.730
430	0	.00	.0	100.0	.656	-3.648
435	0	.00	.0	100.0	.664	-3.567
440	0	.00	.0	100.0	.672	-3.486
445	0	.00	.0	100.0	.679	-3.405
450	0	.00	.0	100.0	.687	-3.323
455	0	.00	.0	100.0	.695	-3.242
460	0	.00	.0	100.0	.702	-3.161
465	0	.00	.0	100.0	.710	-3.080
470	0	.00	.0	100.0	.717	-2.999
475	0	.00	.0	100.0	.725	-2.917
480	0	.00	.0	100.0	.733	-2.836
485	0	.00	.0	100.0	.740	-2.755
490	0	.00	.0	100.0	.748	-2.674
495	0	.00	.0	100.0	.756	-2.593
500	0	.00	.0	100.0	.763	-2.511
505	0	.00	.0	100.0	.771	-2.430
510	0	.00	.0	100.0	.779	-2.349
515	0	.00	.0	100.0	.786	-2.268
520	0	.00	.0	100.0	.794	-2.186
525	0	.00	.0	100.0	.801	-2.105
530	0	.00	.0	100.0	.809	-2.024
535	0	.00	.0	100.0	.817	-1.943
540	0	.00	.0	100.0	.824	-1.862
545	0	.00	.0	100.0	.832	-1.780
550	0	.00	.0	100.0	.840	-1.699
555	0	.00	.0	100.0	.847	-1.618
560	0	.00	.0	100.0	.855	-1.537
565	0	.00	.0	100.0	.863	-1.455
570	0	.00	.0	100.0	.870	-1.374
575	0	.00	.0	100.0	.878	-1.293
580	0	.00	.0	100.0	.885	-1.212
585	0	.00	.0	100.0	.893	-1.131
590	0	.00	.0	100.0	.901	-1.049
595	0	.00	.0	100.0	.908	-.968
600	0	.00	.0	100.0	.916	-.887
605	0	.00	.0	100.0	.924	-.806

			.0	100.0	.931	-.724
615	0	.00	.0	100.0	.939	-.643
620	0	.00	.0	100.0	.947	-.562
625	0	.00	.0	100.0	.954	-.481
630	0	.00	.0	100.0	.962	-.400
635	0	.00	.0	100.0	.970	-.318
640	0	.00	.0	100.0	.977	-.237
645	0	.00	.0	100.0	.985	-.156
650	176	99.43	99.4	.5	.992	-.075
655	0	.00	99.4	.5	1.000	.005
660	0	.00	99.4	.5	1.008	.087
665	0	.00	99.4	.5	1.015	.168
670	0	.00	99.4	.5	1.023	.249
675	0	.00	99.4	.5	1.031	.330
680	0	.00	99.4	.5	1.038	.412
685	0	.00	99.4	.5	1.046	.493
690	0	.00	99.4	.5	1.054	.574
695	0	.00	99.4	.5	1.061	.655
700	0	.00	99.4	.5	1.069	.736
705	0	.00	99.4	.5	1.076	.818
710	0	.00	99.4	.5	1.084	.899
715	0	.00	99.4	.5	1.092	.980
720	0	.00	99.4	.5	1.099	1.061
725	0	.00	99.4	.5	1.107	1.143
730	0	.00	99.4	.5	1.115	1.224
735	0	.00	99.4	.5	1.122	1.305
740	0	.00	99.4	.5	1.130	1.386
745	0	.00	99.4	.5	1.138	1.467
750	0	.00	99.4	.5	1.145	1.549
755	0	.00	99.4	.5	1.153	1.630
760	0	.00	99.4	.5	1.160	1.711
765	0	.00	99.4	.5	1.168	1.792
770	0	.00	99.4	.5	1.176	1.873
775	0	.00	99.4	.5	1.183	1.955
780	0	.00	99.4	.5	1.191	2.036
785	0	.00	99.4	.5	1.199	2.117
790	0	.00	99.4	.5	1.206	2.198
795	0	.00	99.4	.5	1.214	2.280
800	0	.00	99.4	.5	1.222	2.361
805	0	.00	99.4	.5	1.229	2.442
810	0	.00	99.4	.5	1.237	2.523
815	0	.00	99.4	.5	1.244	2.604
820	0	.00	99.4	.5	1.252	2.686
825	0	.00	99.4	.5	1.260	2.767
830	0	.00	99.4	.5	1.267	2.848
835	0	.00	99.4	.5	1.275	2.929
840	0	.00	99.4	.5	1.283	3.011
845	0	.00	99.4	.5	1.290	3.092
850	0	.00	99.4	.5	1.298	3.173
855	0	.00	99.4	.5	1.306	3.254
860	0	.00	99.4	.5	1.313	3.335
865	0	.00	99.4	.5	1.321	3.417
870	0	.00	99.4	.5	1.328	3.498
875	0	.00	99.4	.5	1.336	3.579
880	0	.00	99.4	.5	1.344	3.660
885	0	.00	99.4	.5	1.351	3.742
890	0	.00	99.4	.5	1.359	3.823
895	0	.00	99.4	.5	1.367	3.904
900	0	.00	99.4	.5	1.374	3.985
905	0	.00	99.4	.5	1.362	4.066
910	0	.00	99.4	.5	1.390	4.148
915	0	.00	99.4	.5	1.397	4.229
920	0	.00	99.4	.5	1.405	4.310
925	0	.00	99.4	.5	1.413	4.391
930	0	.00	99.4	.5	1.420	4.472
935	0	.00	99.4	.5	1.428	4.554

940	0	.00	99.4	.5	1.435	4.635
945	0	.00	99.4	.5	1.443	4.716
950	0	.00	99.4	.5	1.451	4.797
955	0	.00	99.4	.5	1.458	4.879
960	0	.00	99.4	.5	1.466	4.960
965	0	.00	99.4	.5	1.474	5.041
970	0	.00	99.4	.5	1.481	5.122
975	0	.00	99.4	.5	1.489	5.203
980	0	.00	99.4	.5	1.497	5.285
985	0	.00	99.4	.5	1.504	5.366
990	0	.00	99.4	.5	1.512	5.447
995	0	.00	99.4	.5	1.519	5.528
1000	0	.00	99.4	.5	1.527	5.610
1005	0	.00	99.4	.5	1.535	5.691
1010	0	.00	99.4	.5	1.542	5.772
1015	0	.00	99.4	.5	1.550	5.853
1020	0	.00	99.4	.5	1.558	5.934
1025	0	.00	99.4	.5	1.565	6.016
1030	0	.00	99.4	.5	1.573	6.097
1035	0	.00	99.4	.5	1.581	6.178
1040	0	.00	99.4	.5	1.588	6.259
1045	0	.00	99.4	.5	1.596	6.340
1050	0	.00	99.4	.5	1.603	6.422
1055	0	.00	99.4	.5	1.611	6.503
1060	0	.00	99.4	.5	1.619	6.584
1065	0	.00	99.4	.5	1.626	6.665
1070	0	.00	99.4	.5	1.634	6.747
1075	0	.00	99.4	.5	1.642	6.828
1080	0	.00	99.4	.5	1.649	6.909
1085	0	.00	99.4	.5	1.657	6.990
1090	0	.00	99.4	.5	1.665	7.071
1095	0	.00	99.4	.5	1.672	7.153
1100	0	.00	99.4	.5	1.680	7.234
1105	0	.00	99.4	.5	1.687	7.315
1110	0	.00	99.4	.5	1.695	7.396
1115	0	.00	99.4	.5	1.703	7.478
1120	0	.00	99.4	.5	1.710	7.559
1125	0	.00	99.4	.5	1.718	7.640
1130	0	.00	99.4	.5	1.726	7.721
1135	0	.00	99.4	.5	1.733	7.802
1140	0	.00	99.4	.5	1.741	7.884
1145	0	.00	99.4	.5	1.749	7.965
1150	0	.00	99.4	.5	1.756	8.046
1155	0	.00	99.4	.5	1.764	8.127
1160	0	.00	99.4	.5	1.771	8.209
1165	0	.00	99.4	.5	1.779	8.290
1170	0	.00	99.4	.5	1.787	8.371
1175	0	.00	99.4	.5	1.794	8.452
1180	0	.00	99.4	.5	1.802	8.533
1185	0	.00	99.4	.5	1.810	8.615
1190	0	.00	99.4	.5	1.817	8.696
1195	0	.00	99.4	.5	1.825	8.777
1200	0	.00	99.4	.5	1.833	8.858
1205	0	.00	99.4	.5	1.840	8.939
1210	0	.00	99.4	.5	1.848	9.021
1215	0	.00	99.4	.5	1.856	9.102
1220	0	.00	99.4	.5	1.863	9.183
1225	0	.00	99.4	.5	1.871	9.264
1230	0	.00	99.4	.5	1.878	9.346
1235	0	.00	99.4	.5	1.886	9.427
1240	0	.00	99.4	.5	1.894	9.508
1245	0	.00	99.4	.5	1.901	9.589
1250	0	.00	99.4	.5	1.909	9.670
1255	0	.00	99.4	.5	1.917	9.752
1260	0	.00	99.4	.5	1.924	9.833
[illegible]	0	.00	99.4	[illegible]	[illegible]	

1270	0	.00	99.4	.5	1.940	9.995
1275	0	.00	99.4	.5	1.947	10.077
1280	0	.00	99.4	.5	1.955	10.158
1285	0	.00	99.4	.5	1.962	10.239
1290	0	.00	99.4	.5	1.970	10.320
1295	0	.00	99.4	.5	1.978	10.401
1300	0	.00	99.4	.5	1.985	10.483
1305	0	.00	99.4	.5	1.993	10.564
1310	0	.00	99.4	.5	2.001	10.645
1315	0	.00	99.4	.5	2.008	10.726
1320	0	.00	99.4	.5	2.016	10.807
1325	0	.00	99.4	.5	2.024	10.889
1330	0	.00	99.4	.5	2.031	10.970
1335	0	.00	99.4	.5	2.039	11.051
1340	0	.00	99.4	.5	2.046	11.132
1345	0	.00	99.4	.5	2.054	11.214
1350	0	.00	99.4	.5	2.062	11.295
1355	0	.00	99.4	.5	2.069	11.376
1360	0	.00	99.4	.5	2.077	11.457
1365	0	.00	99.4	.5	2.085	11.538
1370	0	.00	99.4	.5	2.092	11.620
1375	0	.00	99.4	.5	2.100	11.701
1380	0	.00	99.4	.5	2.108	11.782
1385	0	.00	99.4	.5	2.115	11.863
1390	0	.00	99.4	.5	2.123	11.945
1395	0	.00	99.4	.5	2.130	12.026
1400	0	.00	99.4	.5	2.138	12.107
1405	0	.00	99.4	.5	2.146	12.188
1410	0	.00	99.4	.5	2.153	12.269
1415	0	.00	99.4	.5	2.161	12.351
1420	0	.00	99.4	.5	2.169	12.432
1425	0	.00	99.4	.5	2.176	12.513
1430	0	.00	99.4	.5	2.184	12.594
1435	0	.00	99.4	.5	2.192	12.676
1440	0	.00	99.4	.5	2.199	12.757
1445	0	.00	99.4	.5	2.207	12.838
1450	0	.00	99.4	.5	2.214	12.919
1455	0	.00	99.4	.5	2.222	13.000
1460	0	.00	99.4	.5	2.230	13.082
1465	0	.00	99.4	.5	2.237	13.163
1470	1	.56	100.0	.0	2.245	13.244

REMAINING FREQUENCIES ARE ALL ZERO

ENCLOSURE (2)

GPSS COMPUTER SIMULATION MODEL

SU SIMULATION PROCESS

SAMPLE CASE 2

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** CP-67 VERSION 3 LEVEL 2  GDS MOD 23 ****************** DEV 00E *************************************** 03/15/74 *** 10.46.25 **
```

USERID GF855

ADDRESS G GILMARTIN PLT 25 %CASE 2#

CREATION DATE 03/15/74 10.45.21

LOG MESSAGE

CALLDATA OPERATING HOURS ARE 7000AM TO 11030PM DAILY

```
I*************************************7
I*******  C  A  L  L  D  A  T  A  *******7
I*************************************7
                        @.*********7
 GGGGGGGGGG     DDDDDDDDD   /******/SSSSSS
GGGGGGGGGGGG   DDDDDDDDDD/******/SSSSSSSS
GG        GG   DD        /******/       SS
GG             DD        I*****/
GG             DD        I****/SS
GG             DD        I***/ SSSSSSSSS
GG     GGGGG   DD        I**/   SSSSSSSSS
GG     GGGGG   DD        I*/           SSS
GG        GG   DD        I/D            SS
GG        GG   DD        .D    SS       SS
GGGGGGGGGGGG   DDDDDDDDDD      SSSSSSSSSSSS
 GGGGGGGGGG    DDDDDDDDD        SSSSSSSSSS
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 GGGGGGGGGG   RRRRRRRRRRR    8888888888   555555555555  555555555555
GGGGGGGGGGGG  RRRRRRRRRRRR  888888888888  555555555555  555555555555
GG        GG  RR        RR  88        88  55            55
GG            RR        RR  88        88  55            55
GG            RR        RR   88      88   55            55
GG            RRRRRRRRRRRR    88888888    555555555     555555555
GG     GGGGG  RRRRRRRRRRR     88888888    5555555555    5555555555
GG     GGGGG  RR     RR      88      88            55            55
GG        GG  RR      RR    88        88            55            55
GG        GG  RR       RR   88        88            55            55
GGGGGGGGGGGG  RR        RR  888888888888  555555555555  555555555555
 GGGGGGGGGG   RR         RR  8888888888   55555555555   55555555555
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 SSSSSSSSSS   TTTTTTTTTTTT   AAAAAAAAAA   RRRRRRRRRRR   TTTTTTTTTTTT
SSSSSSSSSSSS  TTTTTTTTTTTT  AAAAAAAAAAAA  RRRRRRRRRRRR  TTTTTTTTTTTT
SS        SS       TT       AA        AA  RR        RR       TT
SS                 TT       AA        AA  RR        RR       TT
SSS                TT       AA        AA  RR        RR       TT
 SSSSSSSSS         TT       AAAAAAAAAAAA  RRRRRRRRRRRR       TT
  SSSSSSSSS        TT       AAAAAAAAAAAA  RRRRRRRRRRR        TT
         SSS       TT       AA        AA  RR    RR           TT
          SS       TT       AA        AA  RR     RR          TT
SS        SS       TT       AA        AA  RR      RR         TT
SSSSSSSSSSSS       TT       AA        AA  RR       RR        TT
 SSSSSSSSSS        TT       AA        AA  RR        RR       TT
```

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ID GF855 03/15/74 10.45.21 G GILMARTIN PLT 25 %CASE 2#

```
BLOCK                                                                               CARD
NUMBER  *LOC   OPERATION  A,B,C,D,E,F,G            COMMENTS                         NUMBER
               SIMULATE
             1 FUNCTION    RN1,D2                   CONSTANT                            1
        0,1/1.0,1                                                                       2
             2 FUNCTION    RN1,C13                  LOG NORMAL                          3
        0,0/.025,.17/.05,.21/.1,.29/.2,.5/.4,.76/.5,.84/                                4
        .6,1.05/.74,1.26/.87,1.59/.90,2.1/.92,2.52/1.0,5.1                              5
             3 FUNCTION    RN1,C24                  EXPONENTIAL                         6
        0,0/.1,.116/.2,.274/.3,.394/.4,.566/.5,.755/                                    7
        .6,1.02/.7,1.33/.75,1.53/.8,1.78/.84,2.03/                                      8
        .88,2.35/.9,2.55/.92,2.8/.94,3.12/                                              9
        .95,3.32/.96,3.55/.97,3.90/.98,4.33/.99,5.11/                                   10
        .995,5.90/.998,6.89/.999,7.78/1.0,9.0                                           11
             4 FUNCTION    RN1,C29                  NORMAL                              12
        0,0/.023,33/.067,50/.115,59/.159,67/.184,70/.212,73/                            13
        .242,77/.274,80/.309,83/.345,87/.382,90/.421,93/                                14
        .460,96/.5,100/.540,104/.579,107/.618,110/.655,113/                             15
        .691,117/.726,120/.758,123/.788,127/.816,130/                                   16
        .841,133/.885,142/.933,150/.977,167/1.0,200                                     17
             1 TABLE       M1,0,5,1000              TIME EM/PA IN ROUTINE               18
             2 FVARIABLE   P5*67/100+V3             *   NORMAL                          19
             3 FVARIABLE   P5*33/100*FN4/100        *   DISTRIBUTION                    20
1              GENERATE    4368,,1,,,,F             20 MISSIONS A YEAR                  21
2              ADVANCE     5                        MOVE EM/PA TO SU                    22
3              ASSIGN      5,55                                                         23
4              ADVANCE     V2                       MATE EM/PA TO SU                    24
5              ASSIGN      5,60                                                         25
6              ADVANCE     V2                       POWER UP SU                         26
7              ADVANCE     310,FN3                  MONITOR ALL SYSTEMS                 27
8              ADVANCE     70,FN3                   SECURE FROM C/O                     28
9              TABULATE    1                        TIME EM/PA IN SYSTEM                29
10             ASSIGN      5,10                                                         30
11             ADVANCE     V2                       MOVE MATED SU/EM/PA                 31
12             TERMINATE                            LEAVE SYSTEM                        32
13             GENERATE    876000                   SIMULATE FOR 10 YEARS               33
14             TERMINATE   1                                                            34
               START       1                                                            35
               CLEAR                                                                    36
             3 FUNCTION    RN1,D2                   CONSTANT                            37
        0,1/1.0,1                                                                       38
             2 FVARIABLE   P5                                                           39
               START       1                                                            40
               END                                                                      41
                                                                                        42
```

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RELATIVE CLOCK 870000 ABSOLUTE CLOCK 870000

BLOCK COUNTS

BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL
1	0	200	11	0	200									
2	0	200	12	0	200									
3	0	200	13	0	1									
4	0	200	14	0	1									
5	0	200												
6	0	200												
7	0	200												
8	0	200												
9	0	200												
10	0	200												

TABLE 1

ENTRIES IN TABLE	MEAN ARGUMENT	STANDARD DEVIATION	SUM OF ARGUMENTS	
200	559.979	347.000	111996.000	NON-WEIGHTED

UPPER LIMIT	OBSERVED FREQUENCY	PER CENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER	MULTIPLE OF MEAN	DEVIATION FROM MEAN
0	0	.00	.0	100.0	-.000	-1.613
5	0	.00	.0	100.0	.008	-1.599
10	0	.00	.0	100.0	.017	-1.584
15	0	.00	.0	100.0	.026	-1.570
20	0	.00	.0	100.0	.035	-1.556
25	0	.00	.0	100.0	.044	-1.541
30	0	.00	.0	100.0	.053	-1.527
35	0	.00	.0	100.0	.062	-1.512
40	0	.00	.0	100.0	.071	-1.498
45	0	.00	.0	100.0	.080	-1.484
50	0	.00	.0	100.0	.089	-1.469
55	0	.00	.0	100.0	.098	-1.455
60	0	.00	.0	100.0	.107	-1.440
65	0	.00	.0	100.0	.116	-1.426
70	0	.00	.0	100.0	.125	-1.412
75	0	.00	.0	100.0	.133	-1.397
80	0	.00	.0	100.0	.142	-1.383
85	0	.00	.0	100.0	.151	-1.368
90	0	.00	.0	100.0	.160	-1.354
95	0	.00	.0	100.0	.169	-1.339
100	0	.00	.0	100.0	.178	-1.325
105	0	.00	.0	100.0	.187	-1.311
110	0	.00	.0	100.0	.196	-1.296
115	1	.49	.4	99.5	.205	-1.282
120	0	.00	.4	99.5	.214	-1.267
125	0	.00	.4	99.5	.223	-1.253
130	1	.49	.9	99.0	.232	-1.239
135	2	.99	1.9	98.0	.241	-1.224
140	0	.00	1.9	98.0	.250	-1.210
145	0	.00	1.9	98.0	.258	-1.195
150	0	.00	1.9	98.0	.267	-1.181
155	0	.00	1.9	98.0	.276	-1.167
160	2	.99	2.9	97.0	.285	-1.152
165	1	.49	3.4	96.5	.294	-1.138
170	2	.99	4.4	95.5	.303	-1.123
175	1	.49	4.9	95.0	.312	-1.109
180	0	.00	4.9	95.0	.321	-1.095
185	0	.00	4.9	95.0	.330	-1.080
190	2	.99	5.9	94.0	.339	-1.066
195	2	.99	6.9	93.0	.348	-1.051
200	1	.49	7.4	92.5	.357	-1.037
205	2	.99	8.4	91.5	.366	-1.022
210	0	.00	8.4	91.5	.375	-1.008
215	1	.49	8.9	91.0	.383	-.994
220	4	1.99	10.9	89.0	.392	-.979
225	0	.00	10.9	89.0	.401	-.965
230	1	.49	11.4	88.5	.410	-.950
235	1	.49	11.9	88.0	.419	-.936
240	1	.49	12.4	87.5	.428	-.922
245	2	.99	13.4	86.5	.437	-.907
250	1	.49	13.9	86.0	.446	-.893
255	4	1.99	15.9	84.0	.455	-.878
260	0	.00	15.9	84.0	.464	-.864
265	1	.49	16.4	83.5	.473	-.850
270	1	.49	16.9	83.0	.482	-.835

```
        CLEAR
3       FUNCTION    RN1    D2
0         1             1.0         1
2       FVARIABLE   P5
        START       1
```

RELATIVE CLOCK 870000 ABSOLUTE CLOCK 870000

BLOCK COUNTS

BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL
1	0	200	11	0	200									
2	0	200	12	0	200									
3	0	200	13	0	1									
4	0	200	14	0	1									
5	0	200												
6	0	200												
7	0	200												
8	0	200												
9	0	200												
10	0	200												

TABLE 1

ENTRIES IN TABLE	MEAN ARGUMENT	STANDARD DEVIATION	SUM OF ARGUMENTS	
200	500.000	.283	100000.000	NON-WEIGHTED

UPPER LIMIT	OBSERVED FREQUENCY	PER CENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER	MULTIPLE OF MEAN	DEVIATION FROM MEAN
0	0	.00	.0	100.0	-.000	-763.996
5	0	.00	.0	100.0	.009	-746.356
10	0	.00	.0	100.0	.019	-728.716
15	0	.00	.0	100.0	.029	-711.075
20	0	.00	.0	100.0	.039	-693.436
25	0	.00	.0	100.0	.049	-675.796
30	0	.00	.0	100.0	.059	-658.156
35	0	.00	.0	100.0	.069	-640.516
40	0	.00	.0	100.0	.079	-622.876
45	0	.00	.0	100.0	.089	-605.236
50	0	.00	.0	100.0	.099	-587.596
55	0	.00	.0	100.0	.109	-569.956
60	0	.00	.0	100.0	.119	-552.316
65	0	.00	.0	100.0	.129	-534.677
70	0	.00	.0	100.0	.139	-517.036
75	0	.00	.0	100.0	.149	-499.396
80	0	.00	.0	100.0	.159	-481.757
85	0	.00	.0	100.0	.159	-464.116
90	0	.00	.0	100.0	.179	-446.477
95	0	.00	.0	100.0	.189	-428.837
100	0	.00	.0	100.0	.199	-411.197
105	0	.00	.0	100.0	.209	-393.557
110	0	.00	.0	100.0	.219	-375.917
115	0	.00	.0	100.0	.229	-358.277
120	0	.00	.0	100.0	.239	-340.637
125	0	.00	.0	100.0	.250	-322.997
130	0	.00	.0	100.0	.259	-305.357
135	0	.00	.0	100.0	.269	-287.717
140	0	.00	.0	100.0	.279	-270.077
145	0	.00	.0	100.0	.289	-252.437
150	0	.00	.0	100.0	.299	-234.797
155	0	.00	.0	100.0	.309	-217.157
160	0	.00	.0	100.0	.319	-199.517
165	0	.00	.0	100.0	.329	-181.877
170	0	.00	.0	100.0	.339	-164.237
175	0	.00	.0	100.0	.349	-146.597
180	0	.00	.0	100.0	.359	-128.957
185	0	.00	.0	100.0	.369	-111.317
190	0	.00	.0	100.0	.379	-93.677
195	0	.00	.0	100.0	.389	-76.037
200	0	.00	.0	100.0	.399	-58.397
205	0	.00	.0	100.0	.409	-40.757
210	0	.00	.0	100.0	.419	-23.117
215	0	.00	.0	100.0	.429	-5.478
220	0	.00	.0	100.0	.439	-987.837
225	0	.00	.0	100.0	.449	-970.197
230	0	.00	.0	100.0	.459	-952.558
235	0	.00	.0	100.0	.469	-934.917
240	0	.00	.0	100.0	.479	-917.278
245	0	.00	.0	100.0	.489	-899.638
250	0	.00	.0	100.0	.500	-881.998
255	0	.00	.0	100.0	.509	-864.358
260	0	.00	.0	100.0	.519	-846.718
265	0	.00	.0	100.0	.529	-829.078
270	0	.00	.0	100.0	.539	[illegible]

OPS MODEL STUDY

APPENDIX C

AUTOMATION OF MODELING TECHNIQUES

REPORT NO. SU OPS-RP-73-0002C

PREPARED FOR THE

GEORGE C. MARSHALL SPACE FLIGHT CENTER
HUNTSVILLE, ALABAMA

CONTRACT NUMBER

NAS 8-30302

PREPARED BY

GRUMMAN AEROSPACE CORPORATION
BETHPAGE, L. I., N. Y.

DATE: 5 November 1973

OPS MODEL STUDY

APPENDIX C

TABLE OF CONTENTS

APPENDIX C

1.0 STUDY TASK

This task examines the feasibility of automating modeling te techniques for the purpose of determining capacities and quantities.

2.0 INTRODUCTION

NASA has found themselves in a situation where a requirement exists to perform a large number of computer simulation runs. Each one of these runs postulate and examine a different "what if" situation. For example, various quantities of support modules, pallets, tunnels, experiment modules, maintenance facilities, etc. must be analyzed to determine the effect on the overall Sortie Lab's avility to meet the mission requirements.

Because of the constraints and limitations involved in the use of their computer systems (UNIVAC 1108 and the IBM 7094) NASA has found it desirable to automate their computer simulation runs. Essentially this involves the automatic passing of output statistics from one run to the next run in order to establish new constraints on the system. Normally this passing of information is accomplished by introducing a man into the loop. He examines the output statistics from a given simulation run, establishes new constraints based on these statistics, introduces the new constraints into the simulation model and then runs the new "what if" condition. This process is repeated over and over many times until all of the viable alternatives are analyzed. This iteration technique rapidly becomes very tedious when even a moderate number of variables are being analyzed, because the number of different combinations becomes unwieldy

2.0 INTRODUCTION (continued)

GAC has performed an analysis to determine the feasibility of automating the GPSS computer simulation runs. Different techniques were tried and the results are presented in the discussion which follows.

3.0 DISCUSSION

Two different approaches were tried to automatically determine an optimum size or capacity of various equipment or facilities ("STORAGES") within the model.

The first approach was to run the model unconstrained in the first simulation. Upon completion, place the maximum contents of a given "STORAGE" into a "SAVEVALUE" where it could be passed to the next run after a selective "CLEAR" or "RESET" card. In the second simulation (after the "CLEAR" or "RESET") the contents of the "SAVEVALUE" "j" (X_j) was then referred to in the storage definition card. This unfortunately was unsuccessful. The storage definition card cannot have an argument indirectly addressed or specified. The capacity of the "STORAGE" wound up being the Value "j" rather than the contents of "SAVEVALUE"-j.

A slight variation of the above was also tried. Instead of using the contents of SAVEVALUE "j" as the argument of the storage definition card, a VARIABLE statement was used. This approach proved unsuccessful as did the above for the same reason.

The second approach was similar to the first in that the maximum contents of a given "STORAGE" under study was placed in a "SAVEVALUE" and passed to the next sequential run. This time, instead of trying to use the data in the "SAVEVALUE" directly as the capacity, the storage was pre-loaded by an amount equivalent to the old capacity less the value in the "SAVEVALUE" X_j.

EXAMPLE:

RUN - 1

INPUT: Capacity Store #2 = 100 (larger than necessary essentially unconstrained)

OUTPUT: MAX Contents = 5

SAVEVALUE #1 = 5.

RESET (or CLEAR X1)

RUN - 2

INPUT: Capacity Store #2 = 100

Preload Store #2 with 95 (100-5) Units

Filter Out Transactions from RUN -1

OUTPUT: MAX Contents = 5 (same as RUN -1)

Observe Mission Reqmt's still being met

RESET (or clear X1)

RUN - 3

INPUT: Capacity Store #2 = 100

Preload Store #2 with One (1) more than Run - 2 (95 + 1 = 96)

Filter out transactions from RUN -2.

OUTPUT: Observe Mission Reqmt's still being met

Reset (or clear X1)

APPENDIX C

RUN - 4

(END)

INPUT: Capacity Store #2 = 100

Preload Store #2 with one (1) more than previous run

Filter out transactions from previous run

OUTPUT: Observe Mission Reqmt's still being met

Reset (or clear X1)

This approach was reasonably successful in that the specified objective was accomplished, that is, the effective capacity of the "STORAGE" was determined based upon the output of a previous simulation The output statistics for the "STORAGE" in question, however, become distorted since the STORAGE had contained 95 dummy Transactions from time "t"=0.

The statistics that resulted can be & were modified "off line" to reflect the desired situation (capacity of storage #2 = 5, 4, 3,- - - - -). Enclosure 1 contains a sample GPSS simulation model. Four sequential simulations were run, utilizing the RESET card to end one run & initiate the next.

The storage statistics were modified as per the following formulas:

CAPACITY (MOD.) = SAVEVALUE 1 (for 2nd run, decreasing by 1 each sequential run)

AVG. TIME PER TRANS, (MOD.) = MEAN FROM TABLE #1

ENTRIES (MOD.) = # ENTRIES IN TABLE

AVG. CONTENTS (MOD.) = AVG TIME PER TRANS (MOD) X ENTRIES (MOD)/CLOCK

AVG. UTIL (MOD.) = AVG CONTENTS (MOD.)/CAPACITY (MOD)

MAX CONTENTS (MOD.) = MAX CONTENTS - PRELOAD

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APPENDIX C

RUN - 1 (STATISTICS NOT MODIFIED)

STORE - 2

CAPACITY (MOD.)	-	100
AVG. TIME PER TRANS (MOD)	-	25.25
ENTRIES (MOD)	-	287
AVG CONTENTS (MOD)	-	2.415
AVG UTILIZATION (MOD)	-	.024
MAX CONTENTS (MOD)	-	5

RUN - 2

STORE - 2

CAPACITY (MOD)	-	5 (100 - 95)
AVG TIME PER TRANS (MOD)	-	25.202
ENTRIES (MOD)	-	292
AVG CONTENTS (MOD)	-	2.45 (25.202 x 292/3000)
AVG UTILIZATION (MOD)	-	49% (2.45/5)
MAX CONTENTS (MOD)	-	3 (98 - 95)

RUN - 3

STORE - 2

CAPACITY (MOD)	-	4 (5 - 1)
AVG TIME PER TRANS (MOD)	-	25.506
ENTRIES (MOD)	-	302
AVG CONTENTS (MOD)	-	2.56 (25.506 x 302/3000)
AVG UTILIZATION (MOD)	-	64% (2.56/4)
MAX CONTENTS (MOD)	-	4 (100 - 96)

APPENDIX C

RUN - 4

STORE - 2

CAPACITY (MOD)	-	3 (5 - 2)
AVG TIME PER TRANS (MOD)	-	24.887
ENTRIES (MOD)	-	293
AVG CONTENTS (MOD)	-	2.42 (24.887 x 293/3000)
AVG UTILIZATION (MOD)	-	81% (2.42/3)
MAX CONTENTS (MOD)	-	3 (100 - 97)

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It should be pointed out that a "RESET" card, rather than a "CLEAR" card was chosen to separate and reinitiate the different simulations. The "RESET" card in GPSS-III & GPSS-1100 does not alter the contents of "SAVEVALUES" whereas the "CLEAR" card does, it sets everything to zero, including all SAVEVALUES. However, the use of the "RESET" rather than the "CLEAR" creates problems. Besides not destroying the contents of SAVEVALUES it does not destroy any transactions in the model being processed at the time of termination and it sets the storage entry count & maximum contents to the current contents of the store at the time of termination. Both of these characteristics must be negated by programming techniques in order to successfully automate the simulation runs.

First, a "LEAVE" block must be inserted at the very end of the simulation ("t" = 3000) to set the current contents to zero. When the next sequential simulation starts the entry count & maximum contents of the storage will be set to zero (0), instead of picking up the current contents at the end of the previous simulation.

Second, an "ASSIGN" block is used to identify each transaction as belonging to Simulation Run 1, 2, 3, or 4. This is accomplished changing the "B" field of the ASSIGN block for each simulation. A "TEST" block is also used in conjunction with the "ASSIGN" block to filter off any transactions being passed from the previous run.

Third, a table is utilized to measure the transit time through the STORAGE. Both, a "RESET" & "CLEAR" card tend to cause erroneous STORAGE out statistics. The average time per transaction can be lower than the true value. (Note: This is explained in the GPSS-III users Manual; page - 163). The use of a table to measure the average transit time of a transaction through a storage enables the analyst to access the true AVERAGE TIME PER TRANSACTION.

It should be noted that in other versions of GPSS, such as GPSS-360, a selective CLEAR card can be used to separate the different simulation runs. Field "A" of this card specifies which SVAEVALUES should not be changed to zero (0). This selective CLEAR offers the advantages of not having to filter out transactions from the previous run and not having to set the storage to zero before the run terminates.

4.0 COURSE OF ACTION

The above technique allows the analyst to pass data from one simulation to the next, using this data as constraints in the following runs. The problem remains, however, to determine which storages should be examined, and in what order.

Presently, cost seems to be the determining factor. Those STORAGES which represent high cost facilities should be examined first followed by the less costly facilities. The task still remains to determine how this system of priorities should be integrated into the simulation model.

ID GR855 10/29/73 11.54.05 G GILMARTIN PLT 25 (TABLE)

ENCLOSURE (1)

SAMPLE GPSS SIMULATION MODEL

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```
BLOCK                                                                                CARD
NUMBER  *LOC   OPERATION  A,B,C,D,E,F,G              COMMENTS                        NUMBER
                                                                                        1
               SIMULATE                                                                 2
        1      VARIABLE   100-X1                                                        3
        2      VARIABLE   V1+1                                                          4
        3      VARIABLE   V1+2                                                          5
        4      VARIABLE   X1                                                            6
        2      STORAGE    100                                                           7
        1      TABLE      M1,0,1,40                                                     8
 1             GENERATE   10,5                                                          9
 2      JKL    ASSIGN     1,1                                                          10
 3      MNO    TEST GE    P1,1,POR                                                     11
 4             QUEUE      1                                                            12
 5             MARK                                                                    13
 6             ENTER      2                                                            14
 7             DEPART     1                                                            15
 8             ADVANCE    25,10                                                        16
 9             LEAVE      2                                                            17
 10            TABULATE   1                                                            18
 11     POR    TERMINATE                                                               19
 12            GENERATE   3000                                                         20
 13     ABC    SAVEVALUE  1,SM2                                                        21
 14            LEAVE      2,S2                                                         22
 15            TERMINATE  1                                                            23
 16     DEF    GENERATE   3100,,,,10                                                   24
 17     GHI    ENTER      2,V1                                                         25
 18             TERMINATE                                                              26
               START      1                                                            27
               RESET                                                                   28
 2      JKL    ASSIGN     1,2                                                          29
 MULTIPLE DEFINITION OF SYMBOL IN ABOVE CARD
 3      MNO    TEST GE    P1,2,POR                                                     30
 MULTIPLE DEFINITION OF SYMBOL IN ABOVE CARD
 13     ABC    SAVEVALUE  2,SM2                                                        31
 MULTIPLE DEFINITION OF SYMBOL IN ABOVE CARD
 16     DEF    GENERATE   ,,,1,10                                                      32
 MULTIPLE DEFINITION OF SYMBOL IN ABOVE CARD
 17     GHI    ENTER      2,V1                                                         33
 MULTIPLE DEFINITION OF SYMBOL IN ABOVE CARD
               START      1                                                            34
               RESET                                                                   35
 2      JKL    ASSIGN     1,3                                                          36
 MULTIPLE DEFINITION OF SYMBOL IN ABOVE CARD
 3      MNO    TEST GE    P1,3,POR                                                     37
 MULTIPLE DEFINITION OF SYMBOL IN ABOVE CARD
 13     ABC    SAVEVALUE  3,SM2                                                        38
 MULTIPLE DEFINITION OF SYMBOL IN ABOVE CARD
 16     DEF    GENERATE   ,,,1,10                                                      39
 MULTIPLE DEFINITION OF SYMBOL IN ABOVE CARD
 17     GHI    ENTER      2,V2                                                         40
 MULTIPLE DEFINITION OF SYMBOL IN ABOVE CARD
               START      1                                                            41
               RESET                                                                   42
 2      JKL    ASSIGN     1,4                                                          43
 MULTIPLE DEFINITION OF SYMBOL IN ABOVE CARD
 3      MNO    TEST GE    P1,4,POR                                                     44
```

```
MULTIPLE DEFINITION OF SYMBOL IN ABOVE CARD
16        DEF    GENERATE    ,,,1,10                                    45
MULTIPLE DEFINITION OF SYMBOL IN ABOVE CARD
17        GHI    ENTER       2,V3                                       46
MULTIPLE DEFINITION OF SYMBOL IN ABOVE CARD
13        ABC    SAVEVALUE   4,SM2                                      47
MULTIPLE DEFINITION OF SYMBOL IN ABOVE CARD
                 START       1                                          48
                 END                                                    49
```

BLOCK NUMBER	SYMBOL	REFERENCES BY CARD NUMBER			
13	ABC				
16	DEF				
17	GHI				
2	JKL				
3	MNO				
11	PQR	11	30	37	44

```
1       VARIABLE    100-X1
2       VARIABLE    V1+1
3       VARIABLE    V1+2
4       VARIABLE    X1
2       STORAGE     100
1       TABLE       M1      0       1       40
1       GENERATE    10      5
2       ASSIGN      1       1
3       TEST GE     P1      1       11
4       QUEUE       1
5       MARK
6       ENTER       2
7       DEPART      1
8       ADVANCE     25      10
9       LEAVE       2
10      TABULATE    1
11      TERMINATE
12      GENERATE    3000
13      SAVEVALUE   1       SM2
14      LEAVE       2       S2
15      TERMINATE   1
16      GENERATE    3100                            10
17      ENTER       2       V1
18      TERMINATE
        START       1
```

RELATIVE CLOCK 3000 ABSOLUTE CLOCK 3000

BLOCK COUNTS

BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL
1	0	287	11	0	285									
2	0	287	12	0	1									
3	0	287	13	0	1									
4	0	287	14	0	1									
5	0	287	15	0	1									
6	0	287	16	0	0									
7	0	287	17	0	0									
8	2	287	18	0	0									
9	0	285												
10	0	285												

STORAGE	CAPACITY	AVERAGE CONTENTS	AVERAGE UTILIZATION	ENTRIES	AVERAGE TIME/TRAN	CURRENT CONTENTS	MAXIMUM CONTENTS
2	100	2.415	.024	287	25.250		5

CONTENTS OF FULLWORD SAVEVALUES (NON-ZERO)

SAVEVALUE NR,	VALUE	NR,	VALUE	NR,	VALUE	NR,	VALUE	NR,	VALUE
1	5								

QUEUE	MAXIMUM CONTENTS	AVERAGE CONTENTS	TOTAL ENTRIES	ZERO ENTRIES	PERCENT ZEROS	AVERAGE TIME/TRANS	$AVERAGE TIME/TRANS	TABLE NUMBER	CURRENT CONTENTS
1	1	.000	287	287	100.0	.000	.000		

$AVERAGE TIME/TRANS = AVERAGE TIME/TRANS EXCLUDING ZERO ENTRIES

TABLE 1

ENTRIES IN TABLE	MEAN ARGUMENT	STANDARD DEVIATION	SUM OF ARGUMENTS	
285	25.312	5.988	7214.000	NON-WEIGHTED

UPPER LIMIT	OBSERVED FREQUENCY	PER CENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER	MULTIPLE OF MEAN	DEVIATION FROM MEAN
0	0	.00	.0	100.0	-.000	-4.226
1	0	.00	.0	100.0	.039	-4.059
2	0	.00	.0	100.0	.079	-3.892
3	0	.00	.0	100.0	.118	-3.725
4	0	.00	.0	100.0	.158	-3.558
5	0	.00	.0	100.0	.197	-3.392
6	0	.00	.0	100.0	.237	-3.225
7	0	.00	.0	100.0	.276	-3.058
8	0	.00	.0	100.0	.316	-2.891
9	0	.00	.0	100.0	.355	-2.724
10	0	.00	.0	100.0	.395	-2.557
11	0	.00	.0	100.0	.434	-2.390
12	0	.00	.0	100.0	.474	-2.223
13	0	.00	.0	100.0	.513	-2.056
14	0	.00	.0	100.0	.553	-1.889
15	15	5.26	5.2	94.7	.592	-1.722
16	9	3.15	8.4	91.5	.632	-1.555
17	10	3.50	11.9	88.0	.671	-1.388
18	12	4.21	16.1	83.8	.711	-1.221
19	11	3.85	19.9	80.0	.750	-1.054
20	17	5.96	25.9	74.0	.790	-.887
21	11	3.85	29.8	70.1	.829	-.720
22	19	6.66	36.4	63.5	.869	-.553
23	12	4.21	40.7	59.2	.908	-.386
24	20	7.01	47.7	52.2	.948	-.219
25	9	3.15	50.8	49.1	.987	-.052
26	15	5.26	56.1	43.8	1.027	.114
27	11	3.85	59.9	40.0	1.066	.281
28	13	4.56	64.5	35.4	1.106	.448
29	19	6.66	71.2	28.7	1.145	.615
30	9	3.15	74.3	25.6	1.185	.782
31	18	6.31	80.7	19.2	1.224	.949
32	10	3.50	84.2	15.7	1.264	1.116
33	17	5.96	90.1	9.8	1.303	1.283
34	11	3.85	94.0	5.9	1.343	1.450
35	17	5.96	100.0	.0	1.382	1.617

REMAINING FREQUENCIES ARE ALL ZERO

```
        RESET
2       ASSIGN     1     2
3       TEST GE    P1    2     11
13      SAVEVALUE  2     SM2
16      GENERATE                     1     10
17      ENTER      2     V1
        START      1
```

RELATIVE CLOCK 3000 ABSOLUTE CLOCK 6000

BLOCK COUNTS

BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL
1	0	291	11	0	292									
2	0	291	12	0	1									
3	0	291	13	0	1									
4	0	291	14	0	1									
5	0	291	15	0	1									
6	0	291	16	0	1									
7	0	291	17	0	1									
8	1	291	18	0	1									
9	0	292												
10	0	292												

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STORAGE	CAPACITY	AVERAGE CONTENTS	AVERAGE UTILIZATION	ENTRIES	AVERAGE TIME/TRAN	CURRENT CONTENTS	MAXIMUM CONTENTS
2	100	95.413	.954	386	741.554		98

CONTENTS OF FULLWORD SAVEVALUES (NON-ZERO)

SAVEVALUE NR.	VALUE	NR.	VALUE	NR.	VALUE	NR.	VALUE	NR.	VALUE
1	5	2	98						

QUEUE	MAXIMUM CONTENTS	AVERAGE CONTENTS	TOTAL ENTRIES	ZERO ENTRIES	PERCENT ZEROS	AVERAGE TIME/TRANS	$AVERAGE TIME/TRANS	TABLE NUMBER	CURRENT CONTENTS
1	1	.000	291	291	100.0	.000	.000		

$AVERAGE TIME/TRANS = AVERAGE TIME/TRANS EXCLUDING ZERO ENTRIES

TABLE 1

ENTRIES IN TABLE	MEAN ARGUMENT	STANDARD DEVIATION	SUM OF ARGUMENTS	
292	25.202	5.937	7359.000	NON-WEIGHTED

UPPER LIMIT	OBSERVED FREQUENCY	PER CENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER	MULTIPLE OF MEAN	DEVIATION FROM MEAN
0	0	.00	.0	100.0	-.000	-4.244
1	0	.00	.0	100.0	.039	-4.076
2	0	.00	.0	100.0	.079	-3.907
3	0	.00	.0	100.0	.119	-3.739
4	0	.00	.0	100.0	.158	-3.570
5	0	.00	.0	100.0	.198	-3.402
6	0	.00	.0	100.0	.238	-3.234
7	0	.00	.0	100.0	.277	-3.065
8	0	.00	.0	100.0	.317	-2.897
9	0	.00	.0	100.0	.357	-2.728
10	0	.00	.0	100.0	.396	-2.560
11	0	.00	.0	100.0	.436	-2.391
12	0	.00	.0	100.0	.476	-2.223
13	0	.00	.0	100.0	.515	-2.055
14	0	.00	.0	100.0	.555	-1.886
15	18	6.16	6.1	93.8	.595	-1.718
16	14	4.79	10.9	89.0	.634	-1.549
17	8	2.73	13.6	86.3	.674	-1.381
18	5	1.71	15.4	84.5	.714	-1.212
19	20	6.84	22.2	77.7	.753	-1.044
20	10	3.42	25.6	74.3	.793	-.876
21	12	4.10	29.7	70.2	.833	-.707
22	15	5.13	34.9	65.0	.872	-.539
23	11	3.76	38.6	61.3	.912	-.370
24	18	6.16	44.8	55.1	.952	-.202
25	14	4.79	49.6	50.3	.991	-.034
26	18	6.16	55.8	44.1	1.031	.134
27	13	4.45	60.2	39.7	1.071	.302
28	23	7.87	68.1	31.8	1.111	.471
29	11	3.76	71.9	28.0	1.150	.639
30	16	5.47	77.3	22.6	1.190	.808
31	14	4.79	82.1	17.8	1.230	.976
32	8	2.73	84.9	15.0	1.269	1.144
33	15	5.13	90.0	9.9	1.309	1.313
34	20	6.84	96.9	3.0	1.349	1.481
35	9	3.08	100.0	.0	1.388	1.650

REMAINING FREQUENCIES ARE ALL ZERO

```
        RESET
2       ASSIGN      1      3
3       TEST GE     P1     3      11
13      SAVEVALUE   3      SM2
16      GENERATE                          1      10
17      ENTER       2      V2
        START       1
```

RELATIVE CLOCK 3000 ABSOLUTE CLOCK 9000

BLOCK COUNTS

BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL
1	0	302	11	0	302									
2	0	302	12	0	1									
3	0	302	13	0	1									
4	0	302	14	0	1									
5	0	302	15	0	1									
6	0	302	16	0	1									
7	0	302	17	0	1									
8	1	302	18	0	1									
9	0	302												
10	0	302												

STORAGE	CAPACITY	AVERAGE CONTENTS	AVERAGE UTILIZATION	ENTRIES	AVERAGE TIME/TRAN	CURRENT CONTENTS	MAXIMUM CONTENTS
2	100	97.537	.975	398	735.205		100

CONTENTS OF FULLWORD SAVEVALUES (NON-ZERO)

SAVEVALUE NR.	VALUE	NR.	VALUE	NR.	VALUE	NR.	VALUE	NR.	VALUE
1	5	2	98	3	100				

QUEUE	MAXIMUM CONTENTS	AVERAGE CONTENTS	TOTAL ENTRIES	ZERO ENTRIES	PERCENT ZEROS	AVERAGE TIME/TRANS	$AVERAGE TIME/TRANS	TABLE NUMBER	CURRENT CONTENTS
1	1	.000	302	302	100.0	.000	.000		

$AVERAGE TIME/TRANS = AVERAGE TIME/TRANS EXCLUDING ZERO ENTRIES

TABLE 1

ENTRIES IN TABLE	MEAN ARGUMENT	STANDARD DEVIATION	SUM OF ARGUMENTS	
302	25.506	6.015	7703.000	NON-WEIGHTED

UPPER LIMIT	OBSERVED FREQUENCY	PER CENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER	MULTIPLE OF MEAN	DEVIATION FROM MEAN
0	0	.00	.0	100.0	-.000	-4.240
1	0	.00	.0	100.0	.039	-4.073
2	0	.00	.0	100.0	.078	-3.907
3	0	.00	.0	100.0	.117	-3.741
4	0	.00	.0	100.0	.156	-3.575
5	0	.00	.0	100.0	.196	-3.409
6	0	.00	.0	100.0	.235	-3.242
7	0	.00	.0	100.0	.274	-3.076
8	0	.00	.0	100.0	.313	-2.910
9	0	.00	.0	100.0	.352	-2.743
10	0	.00	.0	100.0	.392	-2.577
11	0	.00	.0	100.0	.431	-2.411
12	0	.00	.0	100.0	.470	-2.245
13	0	.00	.0	100.0	.509	-2.079
14	0	.00	.0	100.0	.548	-1.912
15	15	4.96	4.9	95.0	.588	-1.746
16	10	3.31	8.2	91.7	.627	-1.580
17	11	3.64	11.9	88.0	.666	-1.414
18	13	4.30	16.2	83.7	.705	-1.247
19	20	6.62	22.8	77.1	.744	-1.081
20	7	2.31	25.1	74.8	.784	-.915
21	14	4.63	29.8	70.1	.823	-.749
22	11	3.64	33.4	66.5	.862	-.582
23	12	3.97	37.4	62.5	.901	-.416
24	16	5.29	42.7	57.2	.940	-.250
25	12	3.97	46.6	53.3	.980	-.084
26	24	7.94	54.6	45.3	1.019	.082
27	15	4.96	59.6	40.3	1.058	.248
28	20	6.62	66.2	33.7	1.097	.414
29	12	3.97	70.1	29.8	1.136	.580
30	9	2.98	73.1	26.8	1.176	.746
31	15	4.96	78.1	21.8	1.215	.913
32	18	5.96	84.1	15.8	1.254	1.079
33	17	5.62	89.7	10.2	1.293	1.245
34	13	4.30	94.0	5.9	1.332	1.411
35	18	5.96	100.0	.0	1.372	1.578

REMAINING FREQUENCIES ARE ALL ZERO

155A

```
        RESET
 2      ASSIGN      1     4
 3      TEST GE     P1    4      11
16      GENERATE                        1      10
17      ENTER       2     V3
13      SAVEVALUE   4     SM2
        START       1
```

157A

RELATIVE CLOCK 3000 ABSOLUTE CLOCK 12000

BLOCK COUNTS

BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL
1	0	295	11	0	293									
2	0	295	12	0	1									
3	0	295	13	0	1									
4	0	295	14	0	1									
5	0	295	15	0	1									
6	0	295	16	0	1									
7	0	295	17	0	1									
8	3	295	18	0	1									
9	0	293												
10	0	293												

STORAGE	CAPACITY	AVERAGE CONTENTS	AVERAGE UTILIZATION	ENTRIES	AVERAGE TIME/TRAN	CURRENT CONTENTS	MAXIMUM CONTENTS
2	100	98.414	.984	392	753.170		100

CONTENTS OF FULLWORD SAVEVALUES (NON-ZERO)

SAVEVALUE NR.	VALUE	NR.	VALUE	NR.	VALUE	NR.	VALUE	NR.	VALUE
1	5	2	98	3	100	4	100		

QUEUE	MAXIMUM CONTENTS	AVERAGE CONTENTS	TOTAL ENTRIES	ZERO ENTRIES	PERCENT ZEROS	AVERAGE TIME/TRANS	$AVERAGE TIME/TRANS	TABLE NUMBER	CURRENT CONTENTS
1	1	.003	295	289	97.9	.040	2.000		

$AVERAGE TIME/TRANS = AVERAGE TIME/TRANS EXCLUDING ZERO ENTRIES

TABLE

ENTRIES IN TABLE	MEAN ARGUMENT	STANDARD DEVIATION	SUM OF ARGUMENTS	
293	24.887	6.050	7292.000	NON-WEIGHTED

UPPER LIMIT	OBSERVED FREQUENCY	PER CENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER	MULTIPLE OF MEAN	DEVIATION FROM MEAN
0	0	.00	.0	100.0	-.000	-4.113
1	0	.00	.0	100.0	.040	-3.947
2	0	.00	.0	100.0	.080	-3.782
3	0	.00	.0	100.0	.120	-3.617
4	0	.00	.0	100.0	.160	-3.452
5	0	.00	.0	100.0	.200	-3.286
6	0	.00	.0	100.0	.241	-3.121
7	0	.00	.0	100.0	.281	-2.956
8	0	.00	.0	100.0	.321	-2.790
9	0	.00	.0	100.0	.361	-2.625
10	0	.00	.0	100.0	.401	-2.460
11	0	.00	.0	100.0	.441	-2.295
12	0	.00	.0	100.0	.482	-2.129
13	0	.00	.0	100.0	.522	-1.964
14	0	.00	.0	100.0	.562	-1.799
15	12	4.09	4.0	95.9	.602	-1.634
16	10	3.41	7.5	92.4	.642	-1.468
17	12	4.09	11.6	88.3	.683	-1.303
18	22	7.50	19.1	80.8	.723	-1.138
19	14	4.77	23.8	76.1	.763	-.972
20	24	8.19	32.0	67.9	.803	-.807
21	15	5.11	37.2	62.7	.843	-.642
22	10	3.41	40.6	59.3	.883	-.477
23	16	5.46	46.0	53.9	.924	-.311
24	13	4.43	50.5	49.4	.964	-.146
25	12	4.09	54.6	45.3	1.004	.018
26	8	2.73	57.3	42.6	1.044	.183
27	9	2.73	60.0	39.9	1.084	.349
28	15	5.11	65.1	34.8	1.125	.514
29	15	5.11	70.3	29.6	1.165	.679
30	16	5.46	75.7	24.2	1.205	.844
31	19	6.48	82.2	17.7	1.245	1.010
32	13	4.43	86.6	13.3	1.285	1.175
33	11	3.75	90.4	9.5	1.325	1.340
34	16	5.46	95.9	4.0	1.366	1.506
35	12	4.09	100.0	.0	1.406	1.671

REMAINING FREQUENCIES ARE ALL ZERO

ENU

OPS MODEL STUDY

APPENDIX D

CRITIQUE OF NASA'S MODELING OPERATION

REPORT NO. SU-OPS-RP-73-0002D

PREPARED FOR THE

GEORGE C. MARSHALL SPACE FLIGHT CENTER
HUNTSVILLE, ALABAMA

CONTRACT NUMBER

NAS 8-30302

PREPARED BY

GRUMMAN AEROSPACE CORPORATION
BETHPAGE, L. I., N. Y.

DATE: 7 November 1973

APPENDIX D

1.0 STUDY TASK

In this task a critique was performed on the NASA modeling operation.

2.0 INTRODUCTION

A sample GPSS-III Simulation Modes, developed by NASA, was reviewed by GAC as to programming technique and depth of analysis. This particular model was a somewhat outdated version of the "Sortie Lab-Ship and Shoot".

3.0 DISCUSSION

The first part of the simulation is involved with the determination of mission hardware requirements. This process involves a random pick to determine which particular flight, out of a total of 33, is going to be launched. Once the flight is determined various equipment and payloads are chosen in accordance with the particular flight.

This random scheduling routine seems to work quite well; however, it might be more involved than is actually necessary. A predetermined launch schedule, based on payload requirements, would involve considerably less programming and could prove to be more flexible. Since in actual practice the launch schedule will be well thought out and planned in advance, a predetermined schedule seems to be a more realistic approach.

The second part of the simulation represents the actual flow of equipment through the ground operating system. This flow is relatively straight forward, and to a great extent, follows the "English Language" diagram. This routine, however, could be expanded to show more detail in various operations; such as, Inspection, Safing, Integration, etc. Major pieces of equipment and facilities involved with these operations should also be included in the model. This will permit greater visibility into the actual equipment requirements, and the relationship between the equipment and the performance of the total payload ground operations system.

4.0 COURSE OF ACTION

Grumman will continue to review NASA's simulation models as to programming technique and depth of analysis. Once a Sortie Lab baseline is established and a simulation modeling effort begins, Grumman will review the model and make recommendations in order to increase the effectiveness of the model.